


HISTORY
OF
RANDLEIGH FARM

LOCKPORT, NEW YORK

SECOND EDITION

JUNE, 1937





Digitized by the Internet Archive
in 2012 with funding from
LYRASIS Members and Sloan Foundation

RANDLEIGH FARM

Visitors are welcome at Randleigh Farm.
We will be glad to show and explain any
part of our Dairy Plant.

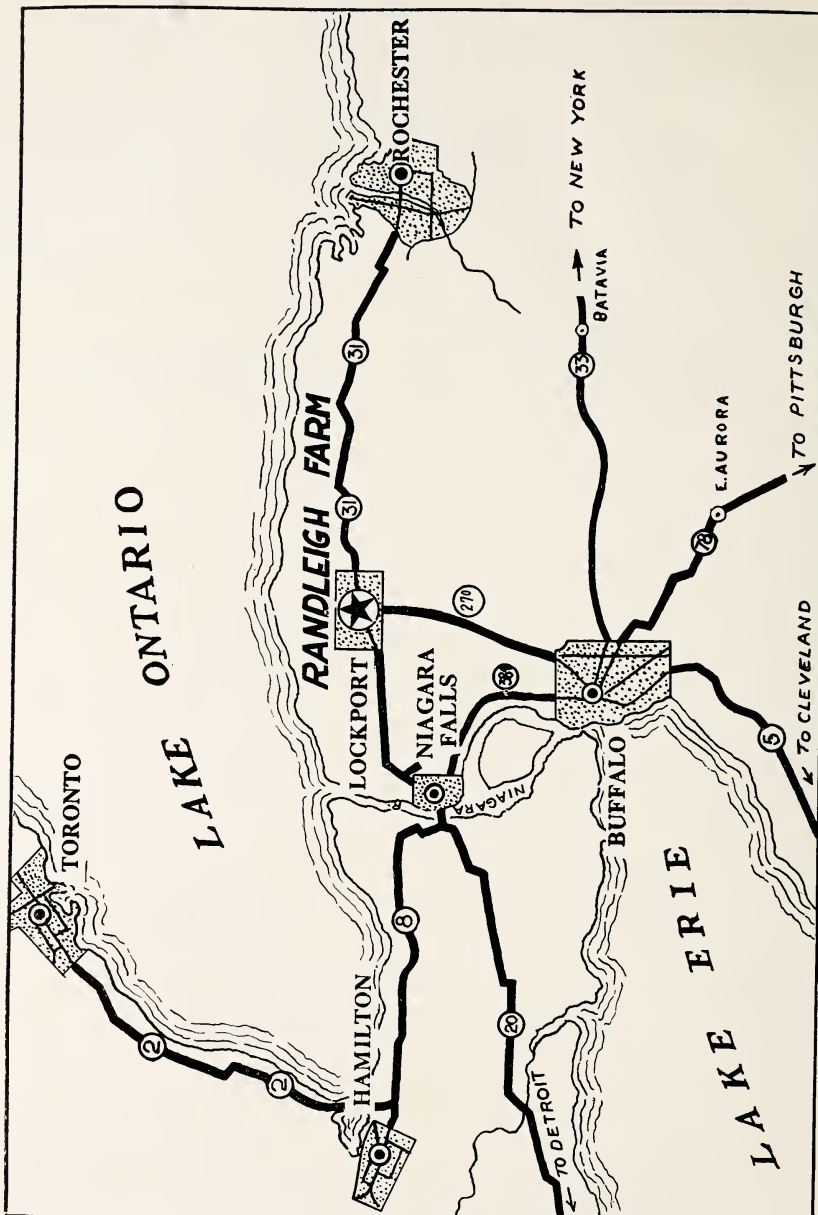
HISTORY
of
RANDLEIGH FARM

SECOND EDITION

LOCKPORT, NEW YORK

JUNE, 1937

Copyright, 1937
By WM. R. KENAN, JR.
All Rights Reserved



Automobile Roads, showing location of Lockport, N. Y.

58 miles west of Rochester
 20 miles east of Niagara Falls
 25 miles northeast of Buffalo

SF

232

.B18 706058

.77

K4

1937

C.2

DEDICATED TO MY WIFE

Alice Pomroy Kenan

who suggested the name Randleigh. This is a constructed word, being composed of my middle name, "Rand," and "Leigh," a Scotch word, meaning a pasture or meadow.

RANDLEIGH FARM

TRADE MARK REGISTERED
IN U. S. AND CANADA

LIST OF ILLUSTRATIONS

PART I

	PAGE
Road Map Showing Location of Lockport.....	6
Air View of Randleigh Farm	14
Sophie's Emily	22
Sophie's Forest Queen	23
A Winter Scene Taken From the Air.....	26
The Test Barn's All-Box Stalls.....	29
The Maternity Stalls	32
The Middle Barn	33
Randleigh Farm Kaschia, Showing Udder and Milk Veins.....	35
The Calf Barn	37
Randleigh Farm Garnet	39
Randleigh Farm Idelia	40
Four Cows in Pasture	41
Dairylike Madcap	43
A View of the Entire Femur Showing Excessive and Irregular Bony Formations	45
A Closer View of the Condyles, Showing the Limited Amount of Smooth Joint Surface	46
A View of the Patella Showing the Many Osseous Changes.....	47
Dairy Inn, Three Outside Views—Front.....	48
Side and Rear	49
Dairy Inn, Three Inside Views—Observation Room "Emily"	51
Observation Room	52
Operator's Room	52
Milking Operation Room, Randleigh Farm Dairy Inn.....	53
The Milk Storage and Mixing Jars	54
Cows in Milking Stalls, Randleigh Farm Dairy Inn.....	55
The Refrigerators, Showing One Air Conditioner	56
Wiring Diagram Showing Only a Portion of Our Apparatus.....	57
The Sterilizer	59
Automatic Bottle Filler Valve	62
An Attempt to Cure Alfalfa Hay With Dry Ice and a Vacuum.....	88
Raying the Cows on the Ramp with National Carbon Co.'s M-1 Type Lamp...	91
Raying the Calves with Paragon Arc Lamps	93
Section of Rats' Teeth With and Without Rickets.....	103
Raying the Cows in the Test Barn with National Carbon Solarium Lamps....	106
Raying the Hydrolized Feeds in Vats With a Blue-Printing Machine Lamp....	107
Raying in the Old Barn With Solarium Lamps.....	109
Automatic Control of These Lamps	110
Figure 1—Thin Ground Longitudinal Section of Rat Mandibula, Enlarged....	131
Figure 2—An Area Corresponding to the Marked Square in Figure 1 in a Tooth in Which the Bone Ash Was 51.32 Percent.....	131
Figure 3—View of an Area of a Tooth Which Gave a Bone Ash Determination of 37.90 Percent	132

LIST OF ILLUSTRATIONS—Continued

	PAGE
Figure 4—Typical Defects in the Dentin Accompanying Lower Bone Ash.....	132
Figure 5—Section of the Mandibular Incisor of Rat No. 1, Group I, Lot "A"..	135
Figure 6—Section of the Mandibular Incisor of Rat No. 2, Group II, Lot "A"..	135
Figure 7—Section of the Mandibular Incisor of Rat No. 1, Group III, Lot "A".	136
Figure 8—Section of the Mandibular Incisor of Rat No. 1, Group IV, Lot "A".	136
Figure 9—Section of the Mandibular Incisor of Rat No. 1, Group I, Lot "B"..	138
Figure 10—Section of the Mandibular Incisor of Rat No. 2, Group II, Lot "B".	138
Figure 11—Section of the Mandibular Incisor of Rat No. 1, Group III, Lot "B".	139
Figure 12—Section of the Mandibular Incisor of Rat No. 1, Group I, Lot "C"..	139
Figure 13—Section of the Mandibular Incisor of Rat No. 2, Group II, Lot "C".	141
Figure 14—Section of the Mandibular Incisor of Rat No. 2, Group III, Lot "C".	141
Figure 15—Section of the Mandibular Incisor of Rat No. 6, Group IV, Lot "C".	142
Doing Their "Daily Dozen" at Randleigh Farm	149
Diagram of New Improved Electric Fly Screen.....	152

PART II

Figure 1—Alternate Feeding with Milk From Cows on Special Feed and Commercial Milk	222
Figure 2—Erythrocyte Response to Dietary Changes in the Same Herd.....	222
Figure 3—Erythrocytes	223
Figure 4—Hemoglobin	223
Rats Receiving Various Milk Diets	230
First Attempts at Drying Green Hay Artificially in the Barn (1904)	236, 237
First Mechanical Hay Drier Made by Jeffrey Manufacturing Company.....	243
Charts Showing Average Gain in Weight of Rats and Average Variation and Rapid Increase in Red Blood Corpuscles	268
Graph Showing the Relation Between Bone Ash and Dose in International Units of Vitamin D	298

INDEX

PART I

HISTORY OF RANDLEIGH FARM		PAGE
Foreword		13
CHAPTER I—		
History		15
The First Cows		15
Hood Farm Sale		17
Randleigh Farm Bought		20
Sophie's Emily		22
Sophie's Forest Queen		23
CHAPTER II—		
Records—Register of Merit Work		36
Randleigh Farm Garnet 773617		39
Randleigh Farm Idelia 909924		40
Dairylike Madcap 646111		43
CHAPTER III—		
The Dairy Inn		48
The Milking Machines		50
Refrigeration		56
Sterilizing Equipment		59
Automatic Bottle Filler Valve		62
CHAPTER IV—		
Feeds		65
Farm-Grown Feeds		69
Mineral Ration Revised		69
Mineral Metabolism (Prof. Erf)		71
Effect of Iodine		74
CHAPTER V—		
Malting or Germinating Grains		76
New Cabinet for Sprouting Grains		76
CHAPTER VI—		
Tests on Pastures		80
CHAPTER VII—		
An Attempt to Cure Green Alfalfa by Means of Dry Ice.....		85
Alfalfa Hay Curing Equipment		87
CHAPTER VIII—		
Ultraviolet Ray		90
CHAPTER IX—		
First Test With Rats (Dr. Scott)		95
Results in Tooth Formation (Dr. Kitchin)		101
CHAPTER X—		
Raying With Solarium Lamps		104
Automatic Control of Lamps in Old Barn.....		108
CHAPTER XI—		
The Sanitary Effect Raying Has On Cows.....		112
CHAPTER XII—		
Second Test With Rats and Chickens.....		114
Results (Dr. Lyman)		117
Conclusions		119
CHAPTER XIII—		
Third Test on Effect of Ultraviolet Irradiation Upon Vitamin D Content of Milk (Dr. Lyman)		122
Experimental Methods		122
Summary and Conclusions		129
Relation Between Bone Ash and Calcification of Dentin in Teeth (Dr. Kitchin)		130

HISTORY OF RANDLEIGH FARM

INDEX—Continued

	PAGE
CHAPTER XIV—	
What Are Vitamins?	143
CHAPTER XV—	
The Control of Mastitis	145
Chemical and Bacteriological Tests	146
CHAPTER XVI—	
Bull Exerciser	148
CHAPTER XVII—	
Electric Fly Screens	150
New Improved Screen	152
CHAPTER XVIII—	
Farm Help	156
CHAPTER XIX—	
Classification of Herd	158
CHAPTER XX—	
The Development of the Sophie Tormentors (Prof. Erf)	165
The Importance of Minerals	165
A Striking Family History	166
Soil Minerals are Important	168
Continuation of the Work	170
CHAPTER XXI—	
The Inherito-Environmental Influence	173
Randleigh Farm Illustration	175
An Example in Fox Breeding	176
CHAPTER XXII—	
The Point of View (Prof. Erf)	179
In Conclusion	183

PART II

FEEDING DAIRY COWS

Foreword—Dean John F. Cunningham	186
Preface	187
CHAPTER XXIII—	
Green Grass	189
Deficiency Diseases	189
Tests at Anna Dean Farm	190
“Green” is the Answer	191
Attempt to Duplicate Grass	191
CHAPTER XXIV—	
Relative Composition of Hays	193
Tops Analyze Highest	193
Effect of Fertilizers	193
Short Pasture Grass Best	194
Juices of Hay	194
Color Factors	195
How “Green” Content Varies	196
CHAPTER XXV—	
Correction of Abnormal Conditions by “Green”	198
Sprouted Grain	198
Supplying Vitamins	200
Heavy Pasture Yields	201
Soiling Methods	201
Hartman Farm Dairy Test	202
Beets—Necessary in the Dairy Ration	204
CHAPTER XXVI—	
Management of Pastures	207
A New Pasture Development	207
Seeding of Pastures	208

INDEX—Continued		PAGE
The Hohenheim System		208
Irrigating Pastures		209
Clipping Pastures		210
CHAPTER XXVII—		
Fertilizing Pastures		212
Iron and “Green” Relationship		212
Iodine Fertilization		214
Iron and Manganese		214
Lime and Acidity		215
Basic Slag		216
Stages of Growth		217
Economy of Pastures		217
CHAPTER XXVIII—		
Nutritional Value of the “Green” of Grass and Hays.....		219
Experiments of Scott, Erf and Delor		220
Experiments with Types of Milk		225
Conclusions from Rat Experiments		231
Cod Liver Oil as a Substitute for “Green”.....		231
The Value of Vitamin E.....		232
Drought Cattle Feeding Test		232
CHAPTER XXIX—		
Hay Preservation		234
First Attempts at Preservation		235
The First Hay Driers		235
Drying in the Bale		239
Other Methods of Hay Drying		241
Modern Driers Tried		242
Preserving Green Hay with Dry Ice		246
Bookwalter Experiment, 1936		250
Randleigh Farm Experiments, 1935, 1936 and 1937.....		251
CHAPTER XXX—		
Definitions and Terms		253
Carotin Needs		253
Hormones		253
Vitamins (Dr. Inman)		254
CHAPTER XXXI—		
History of Milk Business in Relation to Human Health.....		256
History of Feed Business		256
Sanitation Neglected		257
Milk Dealers Arise		258
Cooperation Deemed Necessary		259
Pasteurization is Adopted		260
Effects of Cattle Feeding and Pasteurization on the Food Value of Milk..		262
Safe, Clean Milk		270
CHAPTER XXXII—		
Sanitation and Feeds vs. Pasteurization		272
Food Value Reduced by Pasteurization		272
Nutritious Milk is First Consideration		274
Natural Milk Best		275
Farm Inspection Necessary		278
Health Boards Can Help		279
Pasteurization Alone Insufficient		281
Old Age Might be Postponed		283
CHAPTER XXXIII—		
The Green Plant (Dr. Inman).....		285
CHAPTER XXXIV—		
Blood, Life and The Progress of the Milk Industry (Dr. L. Erf).....		289
APPENDIX—		
Relation Between Bone Ash and Dose in International Units of Vitamin D.		298

FOREWORD

I HAVE expressed the opinion that the basic reason for the dairy business is to supply a highly nutritious health food to mankind, especially to infants and convalescents who depend upon this food entirely, and that much constructive work can be done in a dairy plant used in an experimental way for the practical application of new scientific discoveries in milk production. There are a great many side-lines to the dairy business, but they all hinge upon the basic idea of producing a healthful, nutritious milk.

The driving force behind the efforts at Randleigh Farm has been the thought to accomplish something for humanity. Of course, it has been a process of gradual development and many things have been done which were not even thought of at the beginning.

The staff has been most cooperative and interested, which has helped much. Too much credit cannot be given Professor Oscar Erf, College of Agriculture of Ohio State University, who first came to the farm at my request in August, 1930, and his never-failing interest has helped greatly in our feeding problems and in the designing and equipping of our Dairy Inn.

WILLIAM R. KENAN, JR.

RANDLEIGH FARM, LOCKPORT, NEW YORK

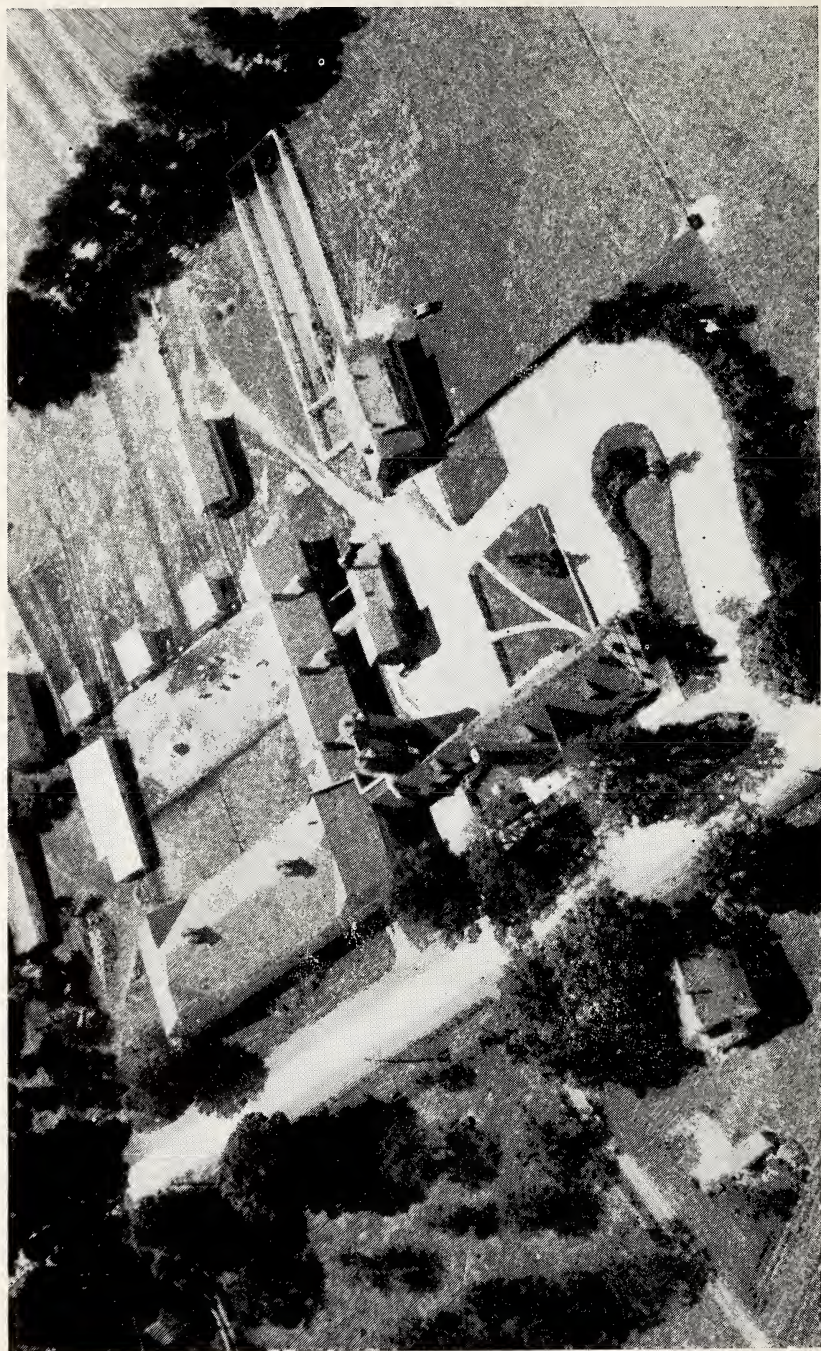
WM. R. KENAN, JR., *Owner*

T. E. GROW, *Superintendent*

F. M. STEDMAN, *Herdsmen*

ESTABLISHED 1922

RANDLEIGH FARM JERSEYS



AN AIR VIEW PICTURE SHOWING THE LAY-OUT OF THE BARNS. THE HOUSES ARE ON THE OPPOSITE SIDE OF THE ROAD

PART I

HISTORY OF RANDLEIGH FARM

LOCKPORT, N. Y.

CHAPTER I.—HISTORY

RANDLEIGH FARM is located on Chestnut Ridge Road (extension of East Avenue) east of the city of Lockport, approximately 3.5 miles from the center of that city. It is composed of 351.95 acres and has five dwelling houses and one boarding house.

About April 1st, 1912, I purchased a residence in the city of Lockport, on what is known as "The Hill," containing 15 $\frac{3}{4}$ acres, and I decided shortly thereafter that we should have a family cow. I visited a number of farms near Lockport and selected a cow from a man by the name of Rutherford (May 17, 1913). This cow happened to be a grade Jersey, for which I paid \$100. Not knowing anything whatever about a dairy cow, I made the selection simply because of the animal's appearance. I was afterward told by the farmer that she was the best milker on the farm and, in his judgment, the best cow he possessed.

The First Cows

The first purchase, although accidental, was the cause of my selecting the Jersey breed. Had the first animal been a Holstein-Friesian, Guernsey or some other breed, I probably would have continued along the same line.

The name of the animal was "Daisy." She died from milk fever shortly after calving in March, 1915. Her heifer calf lived and was named "Daisy 2d." She was raised to be a good family cow.

Should Daisy go dry it would be necessary for us to have another animal and so I secured during July, 1913, "Peg o' My Heart" 294352, an unbred heifer of St. Lambert breeding from the herd of H. M. Flagler, at St. Augustine, Florida, at a cost

of \$140. This animal possessed good type and was a large milker, but, unfortunately, died from milk fever after calving, April 4, 1919. In those days there seemed to be no remedy for milk fever.

During June, 1916, Ralph Keep gave me a grade Jersey heifer calf, which we raised and named "Keepy." It happened that two of these cows became dry at the same time, and so I concluded it would be necessary for me to have a third cow. I looked around for several months and on April 22, 1918, secured from the Larkin Farms, Queenston, Ontario, L. F. Oxford's Vivienne 5823, C. J. C. C., at a cost of \$250. This animal had excellent type, was of Noble of Oakland blood line and a good producer with a Register of Merit record of 5578 pounds of milk and 299.3 pounds of fat. This cow gave us a heifer calf, born April 26, 1919.

Having lost the first two cows that I purchased, I found it necessary, because of the demands at my home, to look around for another cow; and on July 12, 1919, I purchased from Hiram R. Wood, Arlington Farms, Pittsford, N. Y., the Jersey cow "Golinda" 361590, with a Register of Merit record of 6267 pounds of milk, 310.1 pounds of fat. This cow had St. Lambert blood lines and cost \$430. This later purchase was made so that we might have a fresh cow all the time.

By reading the *Rural New Yorker* and *Country Gentleman* I got somewhat interested in Jerseys; and although I did not know anything about them, I determined to have a few family cows at my residence. Through some means my attention was called to Hood Farm, at Lowell, Mass., and on April 15, 1920, I purchased from them Sophie's Forget-Me-Not 387406, with a two-year-old record of 6112 pounds of milk and 371.88 pounds of fat, at a cost of \$950. This animal I considered A-1 from every point of view, with what experience I then had. She gave us a heifer and a bull calf which were sold for two-thirds the price of the cow.

It will be noticed that each cow purchased was better than the ones then owned. I had not thought at this time of having a herd. My definite requirements were for family cows to be used at my residence.

Hood Farm Sale

One day at my office in New York I learned that Hood Farm would have a sale the following day, *i. e.*, June 3, 1920. I determined to attend this sale and purchase one family cow. I took the midnight express to Boston and motored out to Lowell, arriving there in the late morning. I was handed a catalogue containing pictures, pedigrees and records, and as I knew nothing about dairy animals could not judge the information obtained from the catalogue.

The sale was held in a large tent with probably 1500 persons present. I was one of the last to go into the tent and, by way of comment, I might say I did not know a soul on the premises. I sat down on the first row of seats just opposite the auctioneer. Tom Dempsey was the sales manager and Bain was the auctioneer. It was my intention to talk with some individuals there to get a line on what I intended to do but, being late, this opportunity did not present itself.

About the fifth or sixth animal brought into the ring for sale was Sophie's Elberta, a wonderful type animal with every indication of being a large producer. The sale proceeded and all the bidders dropped out, leaving W. J. Gladfelter, Spring Grove, Pa. (now deceased), with a bid of \$3500. I have never been able to figure out just why I commenced to bid as the auctioneer was going to knock this animal down at \$3500, but suffice it to say that before we got through the animal was sold to Mr. Gladfelter for \$6300, only he and I bidding.

I seemed to have gotten the spirit of the occasion, and when the adjournment took place to have lunch I had purchased five cows, one of which was Sophie's Ethna. She was bagged up

so thoroughly that she laid down in the ring, and because of this, every other bidder dropped out and left me with this cow at a price of \$2200. At that time I did not know such a condition is liable to injure the cow. During lunch time quite a number of people asked me where my herd was; if I had a farm and what I intended to do. I had to admit I had no plan, had no farm and only expected to purchase one family cow. The suggestion was made by quite a number that I should have a bull, and when the sale proceeded in the afternoon I did buy Sophie's 19th Son Eleventh 180565, at a price of \$1600.

The following list covers the cows and one bull which I purchased at that sale at a cost of approximately \$7300.

Sophie's Torona Daisy	348580
Raleigh's Little Dorcas	367223
Sophie's Hannah	442763
Sophie's Tormentor Eda	387382
Sophie's Ethna	373758
Sophie's 19th Son Eleventh	180565

All these, strange as it may seem, turned out to be splendid producers and I am sure were worth all the money I paid for them. As a matter of fact, I had pleasure enough to compensate for the money spent if I had not purchased any good cows. By way of passing, I might say that Ethna was one of the best cows I have ever owned and the fact that she was bagged up too heavily did not injure her in the slightest. These animals were expressed to Lockport and taken to my residence where we had three box stalls and a single stall. The cows being on official test at Hood Farm, I concluded to continue this work, notifying Cornell University, Ithaca, N. Y., and arranging the matter.

The men I had on my place were delegated to look after these animals and they were milked twice a day. Ready mixed feed was used and, of course, none of us knew anything about scientific feeding. This plan was carried on during the fall and winter, and I soon concluded that the animals were too good not to have proper attention as no results could be obtained from

the method then in vogue. When I returned from Florida in the spring, I continued to be disappointed with the results and concluded the only thing to do was to get a capable and experienced man to take charge of these animals; and I immediately went East to places doing scientific feeding and testing, with the object in view of securing some one to look after my animals. I did not desire to get a manager or superintendent, but I wanted some one who was actually working in the barns and had technical and scientific knowledge of the work as well as ability to carry it out personally.

I selected two men and, when I offered them the position, neither one seemed inclined to accept, probably due to the uncertainty of a permanent position. However, in the early part of the summer, I was able to make an arrangement with T. E. Grow of Vermont, who was the outside foreman for Hood Farm at Lowell, Mass., and who had previously worked through the barns; and he came here July 1, 1921. He milked, fed, prepared the feed, bed and cleaned 11 cows on official test three times a day. The results were immediate. The interest, thoroughness and efficient manner in which he did his work impressed me so forcibly that I concluded he was too good a man not to have an opportunity; and in the fall of 1921 I commenced to look around for a farm, the cause of which was due to Mr. Grow's work at my residence. He milked the cows three times a day, four, twelve and eight o'clock, from July 1st until the early part of March following, without missing a milking, a record which to my mind is unsurpassed.

All my friends joked me about this move, with the statement that I was laying up trouble for myself and nothing more. As a matter of fact, we have been remarkably free from trouble and have never had any difficulty in securing plenty of competent help at all times.

One of the first things a beginner should learn: never use any paint composed of lead base around cattle and especially

is this true regarding young calves. Always secure paint compounded with a zinc base, and get in the habit of thinking along these lines, irrespective of the kind or color of the paint. This was forcibly impressed upon me by the following experience: At my house in the city we were terribly pressed for room, and I was forced to build a pen for two young calves. We found some interior trim stored away which had been taken out of my house years prior, the building having been painted with white enamel. This seemed exactly suited to our requirements and was used. The result was that within a week we lost both calves. The symptoms indicated poison, and we had all the feed analyzed before we learned the cause of death was due to licking and chewing the enamel paint.

Randleigh Farm Bought

We inspected a great many farms in this locality and, as all the good farms contained fruit, we had some difficulty in getting just what we wanted, being forced to buy and remove fruit trees as years passed. We purchased the farm in November, 1921, but did not obtain possession until March 1, 1922.

There was an old barn on the farm, stone basement, frame superstructure 59 feet wide and 169 feet long. This was thoroughly cleaned out, fumigated and disinfected; and the cattle were taken out there on the 20th day of March, 1922.

On March 1st, Robert Howe of Connecticut, the other man whom I selected originally, came here and joined Mr. Grow as herdsman. At that time Mr. Grow was made superintendent, which position he has held up to the present time.

During the summer Mr. Grow, Mr. Howe and myself gave considerable thought to construction of a test barn, our idea being mainly to produce something which was economical to operate, warm in the winter, and cool in the summer. There was no thought given to this matter from an architectural standpoint. We built a barn at right angles and attached to the old

barn then on the property, 38 feet wide and 135 feet long. This was constructed of brick, lined with hollow tile, the interior being plastered on the hollow tile and painted with oil paint, putty color. We considered the necessity of obtaining plenty of sunshine and good ventilation, and with the latter in mind we got the Jamesway people of Elmira, N. Y., to install the ventilating system, which has proved successful to our entire satisfaction. We used high ceilings, which were covered with Insulite.

These people also furnished the stanchions, partitions and gates. All the box stalls as well as the stanchions had a concrete floor covered with cork brick. The barn was also equipped with individual drinking cups, steam heat and electric fans. It was completed and we moved into it during December, 1922. During this period two silos were constructed of glazed hollow tile 10 feet and 14 feet inside diameters, both 45 feet high.

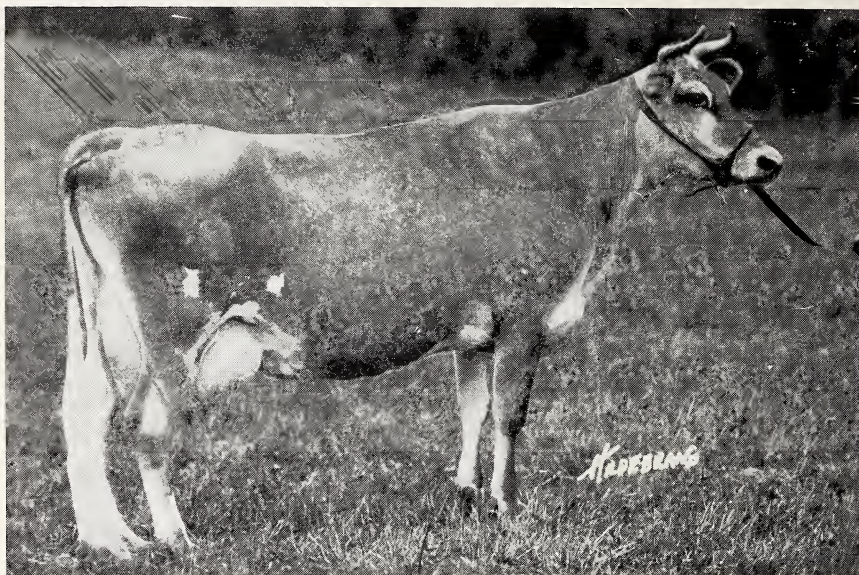
Before starting the construction of the barn we sank a six-inch well incased, which was located inside the new barn. Fortunately we struck an excellent flow of water of good quality, absolutely clear and of a temperature between 55 and 56 degrees F. As the storage tank and all the pipes were placed underground, we have never had any trouble from freezing and the water is the same temperature in both summer and winter.

A rat-proof feed bin with a capacity of about $21\frac{1}{2}$ carloads of grain was constructed in the basement of the old barn adjacent to the test barn. This has proved a great convenience in the economical handling of grain.

Just east of the grain bin in the basement of the old barn we constructed two maternity stalls, the floors being constructed of concrete covered with cork brick. The reason for this location was due to southern exposure to light, cool in the summer and warm in the winter. However, as will be explained later, this was one of the grave mistakes which we made in connection with the construction of our barns.

Later Cattle Purchases

On April 23, 1921—this being just prior to Mr. Grow's arrival here, although I was then trying to persuade him to come



Sophie's Emily 352291

Sire: Pogis 99th of Hood Farm 94502

Dam: Lass 66th of Hood Farm 271896

Winner of five A.J.C.C. Gold Medals

With her lifetime production of 143,348 pounds of milk in nine tests she leads all other cows of the breed and her total of 7,030.31 pounds of fat is exceeded only by the record of her grand-dam, Sophie 19th of Hood Farm.

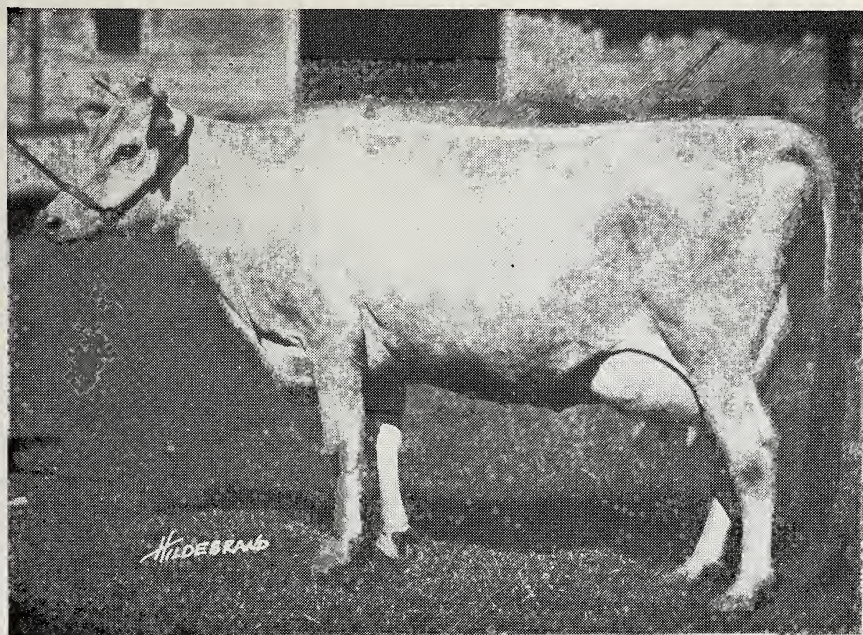
Her remarkable consistency as a producer is best shown in the details of her nine consecutive tests, that are as follows:

<i>Lbs. Milk</i>	<i>Lbs. Fat</i>	<i>Age</i>	<i>Class</i>	<i>Awards</i>
13,792	723.56	2-3	AA	Gold and Silver Medals
14,762	728.05	3-6	A	
15,945	809.77	5-1	AA	Gold Medal
15,148	724.49	6-5	AA	Gold Medal
16,615	800.59	7-8	AA	Gold Medal
16,538	798.55	8-10	A	
17,393	838.93	10-3	A	
17,294	839.86	11-9	AA	Gold Medal
15,861	766.51	13-0	A	

Nine tests total 143,348 pounds milk, 7,030.31 pounds fat.

Nine tests average 15,927 pounds milk, 781.13 pounds fat.

to Lockport—I visited Hood Farm and looked over the herd with Jimmy Dodge, the manager (now deceased). He had a number of animals he was anxious for me to purchase, but stated he would price anything in the barns except old Sophie 19th.



Sophie's Forest Queen 387414

Sire: Pogis 99th of Hood Farm 94502

Dam: Lass 47th of Hood Farm 240327

10,921 lbs. milk, 675.16 lbs. fat, 6.189; 2 yrs. 5 mos., Class A
 15,294 lbs. milk, 911.80 lbs. fat, 5.96; 4 yrs. 10 mos., Class A

After spending a whole day inspecting these animals and listening to his discussion, I stated to Mr. Dodge there were only two animals I was interested in and these he had not considered in his suggestions to me. They were Sophie's Emily 352291 and Sophie's Forest Queen 387414. He protested by saying they were among the best animals in the herd, but after considerable trading I purchased both at a cost of \$6700; and, as they were on official test, it was agreed they were to remain until they had

completed the test, which was done. The results of tests made at Randleigh Farm by these cows proved I made no mistake in obtaining them.

On June 2, 1921, I attended the Meridale sale and purchased the Cid's Merry Lassie 499404, a daughter of the Imported Cid, and Sybil's Christmas Bess 490661, a daughter of Sybil's Gamboge 3d. Both of these animals had considerable type and I desired these blood lines to cross with my Sophie Tormentors. They cost \$1900.

On August 6, 1921, I purchased from Hood Farm, Sophie's Tormentor Elinda 376896, a cow with a remarkable record and in calf to Pogis 99th. I also purchased Randleigh Farm Pogis 202160, a son of Pogis 99th and only a few months old. This bull was out of Sophie's Agnes' Gr. Daughter and had remarkable production on both sides. These animals cost over \$8000.

On May 28, 1922, Mr. Grow and myself made a trip to Lowell and purchased from Hood Farm, Soagson Justine 472958. The progeny of this cow has been remarkable. Her daughters' production records follow:

	<i>Milk</i>	<i>Fat</i>	<i>Days</i>	<i>Class</i>
Randleigh Farm Eloise	13350 lbs.	706.29 lbs.	365	A
Randleigh Farm Daisy	11579 lbs.	587.56 lbs.	365	AA
Randleigh Farm Beth	12387 lbs.	707.07 lbs.	365	AA
Randleigh Farm Garnett	15308 lbs.	848.02 lbs.	305	AA

We also purchased Sobertha Hebe 445752 (both of these animals being bred heifers), and also Sophie's Toronto's Hester 431506. These three animals we believed would assist in building up our herd and in this thought we did not make any mistake. These three animals cost over \$6000.

The following day we went to Ayredale Stock Farm, Bangor, Maine, and purchased St. Mawes Babe of Ayredale 459699, a splendid young animal of Sophie Tormentor breeding.

On September 2, 1922, I purchased of Meridale Farm, Jotta 42657, of Imported Jap breeding, to cross with our Sophie Tormentors. This has proved a great success. This cow gave

birth to a heifer calf before being shipped and we received two animals for the price of one. This heifer, Randleigh Farm Bertha, has average production, but crossed with a Sophie Tormentor produced a medal of merit cow.

On September 16, 1922, Ayredale Stock Farm had a dispersal sale. I attended and purchased the following animals, at a cost of approximately \$6000:

Ayredale Prima Donna	511195
Over-the-Top's Darling	516386
St. Mawes Tisha Babe	300116
Pride's Daisy Pogis	434801
Queen of Ayredale	372451
Sophie's 19th Gr. Daughter	373069

All these animals had Register of Merit records and proved to be splendid producers.

On April 21, 1923, Hood Farm had its dispersal sale and, when we learned of this event, I requested sufficient catalogues for all my boys at the farm, every one being instructed to study the contents and list the animals which, in his judgment, we should purchase, the reasons, and at what price. A meeting was held with Mr. Grow, Mr. Howe, myself and all the boys attending. We digested the records of each animal thoroughly with the result that Mr. Grow and myself attended the sale with the object of securing 10 animals out of about 70 in the sale, and we were successful in purchasing nine. Ed Lasater, of Texas, took the only one we had on the list which we did not get; and in later years Mr. Grow went to Texas and brought this cow back to Randleigh Farm. Following is a list of the animals purchased at the sale at a cost of approximately \$27,000:

Lass 52d of Hood Farm	250689
Sophie's Tormentor Elva	383019
Sophie's 19th Victor	171861
Ayredale Over-the-Top	419983
Sophie's Honey Suckle	445729
Sophie's Tormentor's Isadora	445706
Sophie's Torona's Hagar	435165
Sophie's Agnes' Gr. Daughter	449208
Sodoson Karrie	540438



A WINTER SCENE TAKEN FROM THE AIR

Among them was the top price for a female at the sale and the highest price ever paid for an American-bred bull. These were all of Sophie Tormentor breeding and high producers to such an extent that the results which we in after years obtained were highly satisfactory.

We also leased the old bull Pogis 99th of Hood Farm 94502. During August, 1925, he died and was buried at Randleigh Farm, one of the outstanding animals of the breed.

At this stage of the game we decided it would be highly desirable to bring in some more Island females to cross with our Sophie Tormentors, and on June 23, 1923, at Miss Fitz Gibbons' sale of imported animals, we secured the following, at a cost of \$3200:

Sybil's Gambroyal	579790
Sweet Marguerite the 3d	P.S. 22571-8-C
Golden Daisy Xenia	518126
Sybil's Karnak	555563

These were some of the popular blood lines of that day and were excellent type and also good producers, Sweet Marguerite being the Noble blood line and the Goddington prize winner of the previous year.

At the National Dairy Show held in Syracuse, October 11, 1923, I purchased at auction Sobertha's Harryanna 445733, an extra good Sophie Tormentor cow which was placed in the sale by Mr. Lasater. On November 21, 1923, a good daughter of Xenia's Sultan was obtained from B. H. Bull & Sons, of Brampton, Ontario, Brampton's Xenia's Maiden 598684.

As time went on we saw the necessity of bringing in some new blood and decided to purchase only outstanding animals with exceptionally high records. After a good deal of thought and discussion we concluded to investigate Mr. Lasater's herd of approximately 1800 head at Falfurrias, Texas; and on June 25, 1924, Mr. Grow and Mr. Howe went to Texas upon instruction from me to look over this herd and bring back such animals as in their judgment would prove beneficial to Randleigh Farm.

After spending a week carefully inspecting all these animals they returned with 15 head, costing over \$16,000, as follows:

Sovictor Jeanette	472959
Tormentor's Golden Mary	494937
Sophie's Kathabelle	513936
Sophie's Hopina	445738
Ayredale Aroostook Alda	511199
Sophie's Tormentor Hawena	445749
Sophie's Korelia	535566
Sophie's Luella	564599
Sovictor Idelle 2d	558634
Tormentor's Bright Lady	621569
Sophie's Tormentor's Azurine	558633
Sophie's Tormentor's Lena	614701
Ayredale Jewell 2d	748715
Sovictor Lucia	566800
Agnes Laddie's Lady	599984

All these were of Sophie Tormentor breeding except Tormentor's Bright Lady, which was a cross with a daughter of Combination Premier out of Beauvior Princess, an imported cow.

In order for us to understand the extent of Mr. Lasater's operations, Mr. Grow stated that they motored the better part of four days trying to locate one cow which he afterward purchased.

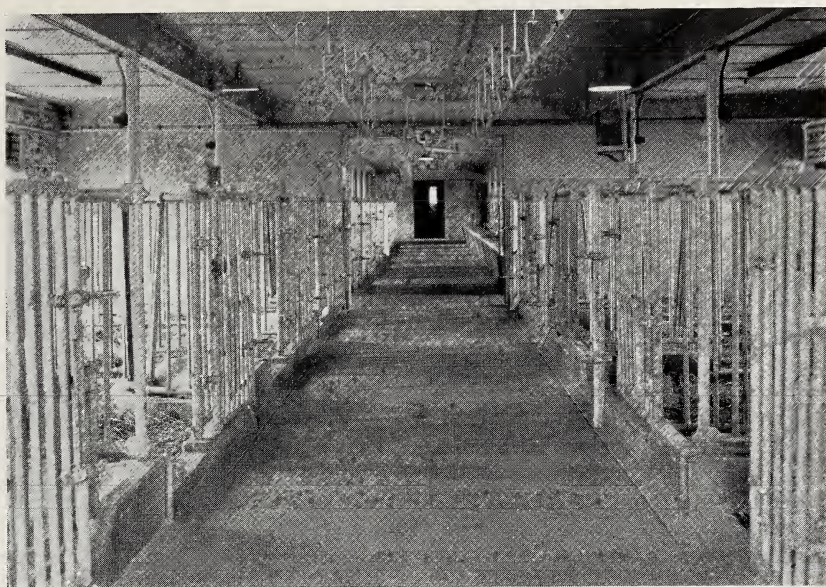
On October 22, 1924, Mr. Grow went to New England and purchased Sovictor Conway Lass 609906, a daughter of our senior herd bull.

The year 1925 was spent in investigating different animals but we did not purchase a single head during the entire year.

On May 11, 1926, Mr. Grow purchased from Mr. Pratt, Golden Fern's Noble Sophy 442029. The reason we wanted this animal was that she was the first daughter of Sophie's Emily, this cow having made a remarkable long-distance record.

On June 1, 1926, I sent Mr. Grow to Columbus, Ohio, and we purchased from Mr. Lasater, who was having a sale at that point, the following animals:

Eastern Azurine	423638
Sovictor Lenore	543955
Sophie's Jackalyn	499198
Tormentor's June Prince F	248080



THE TEST BARN'S ALL-BOX STALLS, 10'2"x14'5"

When constructing the test barn we arranged for the calves to be on the west side, some in individual pens and some in pens of six and eight. As the herd increased the demand for this space became so great that during the summer of 1926 we built a new calf barn, constructed of brick and hollow tile 31 feet wide and 62 feet long (the same type of construction as the test barn), one side composed of individual stalls and the other side of pens with a capacity of six to eight. Heating facilities were provided in this building and it was equipped with Jamesway ventilating system. The barn has proved most successful, is easily heated in winter and very cool in the summer, all the stalls containing cork brick. Adjacent to this barn are three exercising yards, and it is our custom to put these calves out every day the weather will permit, dividing them according to size. We also have arranged to subject these calves each day during the winter months to ultraviolet ray.

On June 22, 1926, I attended the Spann sale at Morristown, N. J., and purchased Fern's Laurels Queeny 700552, of Blonde

Golden Oxford's breeding. On July 19, 1926, we purchased from Reynolds Farm, Brampton Thank Xenia 585162, both of these being imported cows. They cost \$2200.

We learned that Pickard Brothers, Salem, Oregon, were going to have a sale June 23, 1927, and among those animals to be disposed of was Darling's Jolly Lassie 435948. I had met the Pickards and seen this animal at the National Dairy Show at Syracuse, and I felt sure that if I went to Oregon too many people would know me and the result would be a very large price if I really purchased the animal. It was, therefore, concluded that Mr. Grow would make the trip, which he did, looking over all the animals in the sale but without letting any one know who he was or where he came from. He succeeded in obtaining Darling's Jolly Lassie and also purchased Darling Vive Glow 519667. The price we paid for these animals was just about one-half what we had estimated would be necessary to obtain them. Lassie has given us a bull which we are using and three splendid heifers, all with high production.

While Mr. Grow was in Oregon I attended an auction at Meridale Farm, June 27, 1927, and purchased imported Dairy-like Madcap 646111, at a cost of \$5700. This animal, to my mind, combined type and production to a greater extent than has any other Jersey cow I have ever seen. Her donation to Randleigh Farm was far-reaching. She had made a large record and was on test at the time I purchased her, so we concluded to leave her at Meridale Farm until she finished before bringing her here. This plan was carried out. She also made two very creditable records after arriving at Randleigh Farm.

October 18, 1927, Mr. Grow again went to Texas and purchased from Mr. Lasater:

Sophie's Jetty	. . . . .	513626
Sophie's Agnes Laddie	. . . . .	179327

these being straight Sophie Tormentor breeding and Sophie's Agnes Laddie being a proven bull. These two animals cost approximately \$9000.

HISTORY OF RANDLEIGH FARM

May 23, 1928, we purchased from R. R. Graves, Kensington, Md.:

Golden Glow Sophie's Rose	676138
Golden Glow Agnes Prue	791803

good type animals with fair records.

September 24, 1928, we purchased from R. L. Faux, Barre, Mass., for \$7600, the following:

Killingly Torono Lass	508624
Killingly Torono Louise	543422
Killingly Owl Lass	692251

These were exceptionally good animals; the first one holding two world records, has given us a bull calf which we are using at the present time.

On April 2, 1929, I obtained from quarantine, having been imported by Meridale Farm, Dorothy's Marvel 841748. This animal possessed excellent type and showed indications of being a very large milker. She has produced since her arrival at Randleigh Farm 16,295 pounds of milk, 759.29 pounds of fat at five years 11 months. Her sire, Boanerges P.S. 6006-C, is a son of Xenia Sultan.

April 17, 1929, we purchased from R. L. Faux, Killingly Owl's Sally 580709, a good cow.

Because of the necessity for additional room, during the fall of 1927 we constructed a heifer barn (wooden construction), size 20x50 feet which contained tie-ups and was properly ventilated by the Jamesway Company. About the same time we also constructed a building containing four maternity stalls, size 15'21½"x9'0"x8'0" high inside measurements. This was a wooden structure, had concrete floors and foundations with curbing 12 inches high so as to be easily fumigated and disinfected. It should have a hip roof, so as to provide ventilation during the summer and also storage for hay and straw. The roof should have an overhang on the front side of about five feet. This will prevent a driving rain from entering the doors to each



THE MATERNITY STALLS

stall and also provide shade against the hot sun during the summertime. The building should face the south. It should be completely screened, all windows and doors, and it is highly beneficial if one electric fly screen is placed in each stall. This structure is properly insulated and each stall has cross ventilation, making them warm in winter and cool in summer. In this climate these stalls should be heated during the winter. The cows when calving should have a room temperature between 50 and 60 degrees F. The young calves seem to do much better when born in such a temperature. Hot water heating with side-wall radiators on each stall proves satisfactory and is economical to operate.

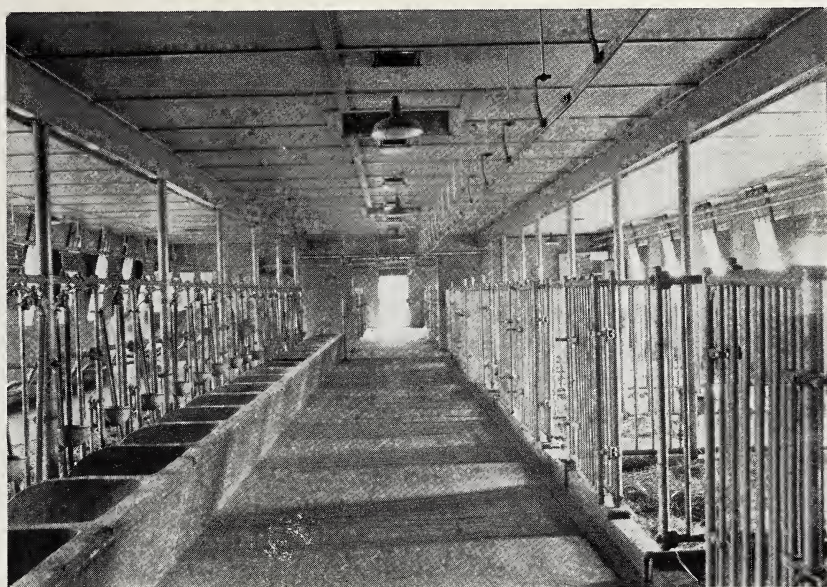
We constructed a hay shed in 1930 in a suitable location, adjacent to the barn, which has proved to be most useful. It was located on a knoll so as to have proper drainage, was con-

HISTORY OF RANDLEIGH FARM

structed of creosoted poles 32 feet high, set in concrete, with a hip roof, having an overhang on all four sides of 31½ feet. The size was 24x36x25 feet high. The gable ends were closed in down to the plate so as to keep out the weather, but one end had a removable door to permit the hay fork to operate easily.

On November 25, 1929, Mr. Grow secured at a cost of \$3260 from J. N. Martin, New Providence, Iowa:

Floss's Duke's Vivian	750176
Tormentor's Floss' Duke	216516



THE MIDDLE BARN

This latter animal was bred by Hood Farm, sold to Mr. Martin as a calf and was a proven bull when obtained by us.

On March 15, 1930, we obtained from Randall Anderson, Youngstown, Ohio, the following:

Pogis 99th Duke Lillian	690379
Pogis 99th Duke Lass	687886
Pogis 99th Blanch	687885

These were all of Sophie Tormentor breeding.

Bob Howe came with us as herdsman March 1, 1922, remaining until March 11, 1930, at which time he was succeeded by Frank Stedman who came with us August 19, 1923, and worked in the test barn. Howe left because he obtained a better job and in accordance with our suggestion. Unfortunately, he died shortly thereafter. He was one of the outstanding men in his line it has been my privilege to meet. Stedman has continued up to the present date as herdsman.

More than four years having elapsed since we purchased any animals, it was thought wise to bring in some new blood, and with this in mind we communicated with Wallace McMonnies during October, 1933, and purchased from him at a cost of \$2065 Reine de Monde 1037667, a Sourette strain which he had on the Island. It was understood she would come over with the first importation during the following year. This animal had never been tested but was a persistent large milker; and it was our intention to breed her, crossing with a Sophie Tormentor bull and also try to make a creditable record at the same time. She calved before she was shipped and was received by us on June 9, 1934, together with her heifer calf, born March 30 and named Blonde's Sourette's Lady, sired by Kabul P.C. 6622-C.

We also purchased at a cost of \$1380 from Crieve Hall Farms, Nashville, Tenn., on May 14, 1934, Carmel Roselle 816263, a daughter of Design's Fern Oxford with two gold medal records, one being 812.54 pounds of fat in 365 days. The purpose was to use her in the same manner as the cow referred to above.

Total cost of animals purchased in stocking Randleigh Farm amounts to \$134,100. Nearly all these animals have passed on and were, of course, charged off, only two animals remaining that were purchased. This includes everything up to December 31, 1936.

The herd is composed of approximately 165 head, with about 60 to 65 cows in milk. In 1935 there were born on the

farm 75 calves. Of these one-half were bull calves, and were sold. We lost very few calves, which was due to proper handling and feeding.

In 1936 there were born on the farm 70 calves. It is not my intention to increase the number of animals in the herd, since these are sufficient to carry out the experimental and demonstration work.

We have never sold a heifer nor a cow until tested. We give every one that freshens a fair test; and if she can not make approximately 500 pounds of fat with first calf, we dispose of her as a good family cow. This plan, together with the sale of old cows not required for breeding purposes each fall, keeps our herd down to approximately 165 head, including calves and bulls.



RANDLEIGH FARM KASCHIA, SHOWING UDDER AND MILK VEINS

CHAPTER II.—RECORDS

REGISTER OF MERIT WORK

IT is our firm conviction that, as a rule, there has been too much emphasis placed on the achievements of some sensational animal and too little upon the performance of the herd as a whole. With this idea in mind every female at Randleigh Farm is given the opportunity of a Register of Merit test as soon as possible after she becomes of milking age. The following table is offered as proof of the producing ability of the herd. It includes every animal tested during the past 14 years, regardless of age or condition.

365-DAY TESTS

<i>Year</i>	<i>No. Tested</i>	<i>Average Milk</i>	<i>Average Fat</i>	<i>Number of 2-Year-Olds</i>
1922	10	11,608	670.41	3
1923	14	12,348	680.01	3
1924	20	11,902	642.11	6
1925	16	12,836	692.85	6
1926	14	11,529	635.90	5
1927	16	12,713	689.94	4
1928	18	11,172	629.13	6
1929	15	11,522	637.78	5
1930	13	11,651	671.22	5
1931	15	11,258	602.66	5
1932	12	10,004	573.89	10
1933	10	11,520	652.72	3
1934	18	11,359	632.22	11
1935	14	11,708	664.78	4

305-DAY TESTS

<i>Year</i>	<i>No. Tested</i>	<i>Average Milk</i>	<i>Average Fat</i>	<i>Number of 2-Year-Olds</i>
1922	1	11,617	611.79	None
1923	3	10,151	533.53	1
1924	3	8,439	436.91	1
1925	8	8,932	471.05	2
1926	6	10,934	579.43	1
1927	8	10,137	562.59	1
1928	11	10,571	550.18	2
1929	10	9,732	496.46	2
1930	11	11,266	606.81	2
1931	13	9,709	542.65	5
1932	17	10,049	540.29	7
1933	10	9,491	526.02	1
1934	12	8,761	498.35	8
1935	21	10,756	594.81	3

In connection with the tables on the preceding page, one fact should be borne in mind, namely, that the foundation at Randleigh Farm was the pick of the best producing herds in the country. These foundation animals have of necessity long ago passed the age of high production and the present milking herd is composed almost entirely of home-bred animals. A comparison of these Register of Merit tests is evidence that we have builded well. These records in a herd of this size are convincing evidence that production with good type not only is possible but in this instance has been attained.



THE CALF BARN

TWENTY-FIVE HIGHEST RECORDS

	<i>Name</i>	<i>Number</i>	<i>No. Days</i>	<i>Milk</i>	<i>Fat</i>	<i>Age</i>
1.	Randleigh Farm Idelia . . .	909924	365	16774	1050.32	3-11
2.	Sovictor Doris	617543	365	18676	946.79	6-2
3.	Sophie's Hopina	445738	365	18166	917.39	7-3
4.	Sophie's Honey Suckle . . .	445729	365	16284	901.87	6-6
5.	Randleigh Farm Carolyn . . .	596897	365	14693	893.65	5-3
6.	Ayredale Aroostook Alda . . .	511199	365	16071	888.61	4-10
7.	Sophie's Korelia	533566	365	15193	878.27	8-0
8.	Randleigh Farm Lass	992774	365	14684	875.98	3-8
9.	S. Tormentor's Isadora . . .	445756	365	14492	871.62	6-2
10.	Sophie 19th's Gr. Daughter . .	373069	365	15177	839.28	7-1
11.	Sophie's Jackalyn	499198	365	15877	860.06	7-1
12.	Sovictor Jeannette	479959	365	15771	851.29	6-8
13.	Pride's Daisy Pogis	434801	365	14918	848.12	6-0
14.	Randleigh Farm Garnet	773617	305	15303	848.10	5-4
15.	Randleigh Farm Idyl	900728	365	14969	843.20	3-3
16.	Sophie's Emily	352291	365	17294	839.86	11-9
17.	Randleigh Farm Ivy	909926	365	13779	836.90	3-4
18.	Randleigh Farm Claudia	610566	365	15083	823.42	6-4
19.	Sophie's Hannah	442763	365	14870	818.42	4-11
20.	Golden Glow Sophie Rose . . .	676138	365	14569	817.95	6-2
21.	Sophie's Ethna	373758	365	16300	815.20	10-4
22.	Imp. Dairylike Madcap	646111	305	13238	810.56	8-9
23.	Randleigh Farm Amelia	1027434	365	14015	802.40	2-7
24.	Randleigh Farm Lucille	1016194	365	13632	797.91	2-2
25.	Sophie's Agnes' Gr. Daughter . .	449208	365	13158	796.47	3-10
Total				382991	21503.63	
Average				15319	860.14	
205 records made at Randleigh Farm average				11704	648.38*	
134 records made at Randleigh Farm average				10123	544.49†	

The American Jersey Cattle Club has awarded to the animals tested at Randleigh Farm the following: 9 Medals of Merit, 64 Gold Medals, 87 Silver Medals.

Shortly after January 1, 1937, there were awarded Randleigh Farm cattle, one Medal of Merit, three Gold Medals and six Silver Medals, in addition to those above.

* 365 days. † 305 days.



Randleigh Farm Garnet 773617

Sire: Randleigh Farm Pogis 202160.

Dam: Soagson Justine 472958.

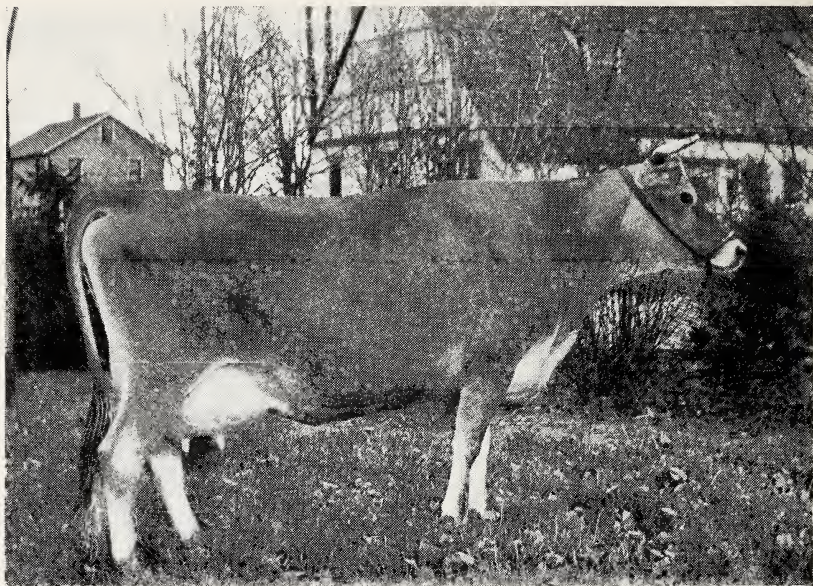
She by a son of Sophie's Agnes and out of a daughter of
Pogis 99th of Hood Farm.

World's Champion Junior 3-year-old 305-day division.

Register of Merit record made in 305 days at 3 years, 5 months of age, 14,666
pounds of milk, 821.56 pounds of fat.

Silver Medal cow with 10,976 pounds of milk, 593.01 pounds of fat made in 305
days at 2 years, 4 months of age.

Bred, owned and tested at Randleigh Farm.



Randleigh Farm Idelia 909924

Sire: Sophie's Agnes Laddie 179327.

Dam: Sovictor Fraulein 734042.

She by Sophie 19th's Victor and out of a daughter of
Carry-on-of-Ayredale.

World's Champion Senior 3-year-old 365-day division.

Register of Merit record made in 365 days at 3 years, 11 months of age, 16,774 pounds of milk, 1,050.32 pounds of fat.

Also 8,607 pounds of milk, 533.14 pounds of fat, 365 days at 2 years, 4 months of age.

This cow is a good tester, averaging 6.26% and 6.19% each record.

Bred, owned and tested at Randleigh Farm.

Note: Since this book was compiled the above record has been exceeded by five pounds of fat.

HISTORY OF RANDLEIGH FARM



Sophie's Emily

Dairylike Madcap

Darling's Jolly Lassie

Killingly Torono Lass

IN THE PASTURE AT RANDLEIGH FARM, JULY, 1930

SOPHIE'S EMILY 352291

Age: 14 Years, 11 Months

<i>Lbs. Milk</i>	<i>Lbs. Fat</i>	<i>In Days</i>	<i>Age</i>	
			<i>Years</i>	<i>Months</i>
13792	732.56	365	2	3
14762	728.05	365	3	6
15945	809.77	365	5	1
15148	724.49	365	6	5
16615	800.59	365	7	8
16338	798.55	365	8	10
17393	838.93	365	10	3
17294	839.86	365	11	9
15861	766.51	365	13	0
143349	7030.31			

H I S T O R Y O F R A N D L E I G H F A R M

DAIRYLIKE MADCAP 646111

Age: 10 Years, 4 Months

<i>Lbs. Milk</i>	<i>Lbs. Fat</i>	<i>In Days</i>	<i>Age</i>	
			<i>Years</i>	<i>Months</i>
15571	960.72	365	5	3
15034	953.03	365	6	7
11704	714.21	305	7	9
13238	810.56	305	8	9

DARLING'S JOLLY LASSIE 435958

Age: 12 Years, 4 Months

<i>Lbs. Milk</i>	<i>Lbs. Fat</i>	<i>In Days</i>	<i>Age</i>	
			<i>Years</i>	<i>Months</i>
8634	554.55	365	2	3
16425	1141.28	365	4	0

KILLINGLY TORONO LASS 508624

Age: 9 Years, 2 Months

<i>Lbs. Milk</i>	<i>Lbs. Fat</i>	<i>In Days</i>	<i>Age</i>	
			<i>Years</i>	<i>Months</i>
8075	464.18	305	2	2
14268	816.87	305	3	3
15556	882.48	305	4	4
17271	958.40	365	5	5
13683	753.15	365	6	8

A quartette of the most remarkable Jersey cows perhaps ever herded at the same time in one pasture.



Dairylike Madcap 646111

During the summer of 1930 we began to be worried about the physical condition of Dairylike Madcap. She had made two tremendous records before we purchased her and continued with this same large production, making two records after she came here. This cow did not dry up and frequently milked 20 pounds when she would calve again. She was a good feeder but apparently was unable to digest and assimilate or properly metabolize sufficient minerals to produce the large quantity of milk she gave, and, therefore, she seemed to take it out of her own constitution.

During the summer she calved but seemed to lose flesh and soon thereafter while running around her paddock broke her hind leg. As she was a relatively old cow, all the veterinarians I consulted suggested she be killed; but I was so impressed with her records that I concluded to make every effort to save her and hence telegraphed Professor Oscar Erf of Ohio State University to come here and try to help us. This was in August, 1930, and

upon his arrival and inspection of the cow he did not offer much encouragement on account of her age (13 years), but was willing to make the effort.

We placed a derrick in her stall and a sling around her body and raised her and lowered her each day for approximately five months. She was fed germinated grains and minerals, primarily calcium, phosphorus, iron and iodine. We also subjected her to the ultraviolet ray for about 10 minutes twice daily by means of portable hand lamps of the carbon pencil type.

Within one year's time, during which period the broken bone had healed, the physical condition was 100 percent (from the standpoint of production and reproduction) and, although she limped (due to misplacements of the tendon attachments) she was able to go around any place that she desired. Her age and the decalcification from excessive milk production permitted the gradual development of a chronic hypertrophic type of arthritis.

This cow produced two living calves fully developed after the experience above, and died during the summer of 1933. Her immediate death was probably due to exhaustion brought on by years of heavy milk production, reproduction and to old age.

When Madcap died we had a post-mortem and found that her bones and especially her joints had been changed to a considerable extent. We noticed before she died that her joints cracked (noise) when she walked, which naturally accounted for the condition described above; and it was a great surprise to all of us that she walked at all. Her ribs were found to be pitted full of holes which were sufficiently deep to feel them through the skin.

The accompanying illustrations of bones were taken soon after Madcap's death, and the description of them along with explanations is given herewith by Dr. Lowell Erf, Cincinnati, who has been at the farm many times with Professor O. Erf and studied Madcap's condition:

"This represents the pathological changes resulting from a bony process occurring during many preceding years. As one can see, there are alternate areas of bony destruction and bony proliferation (the projections or bumps) throughout the shaft



A VIEW OF THE ENTIRE FEMUR SHOWING EXCESSIVE AND IRREGULAR BONY FORMATIONS

and ends of this femur. This end stage of a preceding bony process is similar to the changes seen in osteo-arthritis or hypertrophic arthritis.

"The changes probably occurred in the following sequence: Madcap did not eat sufficient calcium during her heavy milking period and the blood calcium was consequently lowered. Physiologists know that all the bones of animals normally are constantly being torn down by the osteoclasts (bone-destroying cells) and being built up by the osteoblasts (bone-forming cells). When the demand for calcium to the mammary glands of Madcap became sufficiently great the newly laid calcium of the bones was given to the blood plasma. This resulted in soft bones in

areas, allowed ligaments to pull away and also allowed actual bony destruction because pressure (through standing) caused bone anemia (squeezing blood out of the soft bone); and the osteoclasts and osteoblasts were killed or pushed out of their

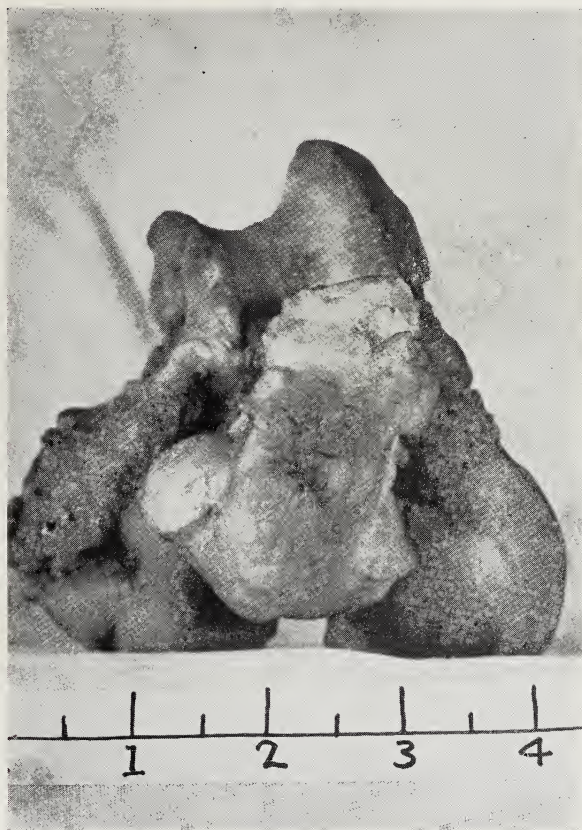


A CLOSER VIEW OF THE CONDYLES, SHOWING THE LIMITED AMOUNT OF SMOOTH JOINT SURFACE. THE SYNOVIAL BONY FRINGES CAN BE SEEN AT THE EDGE OF THE SMOOTH SURFACE

normal positions. During this period infections and toxins could enter, and this allowed more destruction of bone. At this stage the cow could not stand although she continued to give 25 to 30 pounds of milk.

“About this time Professor Erf suggested that ultraviolet rays, calcium, hydrolized feeds, and good hays be given. With this increased ingestion of calcium, that element was again deposited in the bones. Still, in the pressure areas and in the anemic areas and in the destroyed areas, bone could not form and so ‘bumps’ occurred wherever the osteoblasts still remained. Thus irregular bone formed, with the synovial tissues becoming

involved; and this caused synovial fringes to form and reduced the area of smooth surface in the joint, which limited motion. During this stage Madcap had 'grating' sounds in her joints, and she appeared stiff with marked limitation of motion although



A VIEW OF THE PATELLA SHOWING THE MANY OSSEOUS CHANGES

she could get up and walk around and did deliver two more healthy calves.

"So the pictures represent the end stage of this long-drawn-out process with synovial fringes, bony lipping, osteophytes, and alternate areas of bony destruction and over-active bony formation."

CHAPTER III.—THE DAIRY INN

ON THE occasion of some of Professor Erf's visits here, he talked to me at some length about his ideas in connection with a milking parlor, the plan being to take the cows out of the barn when milking. At first I did not take much stock in it, but eventually I seemed to see the light; and during June, July, and August of 1931 we experimented by constructing quite a number of wooden stalls, carrying out the idea of Professor Erf. We developed these far enough that we con-



FRONT OF RANDLEIGH FARM "DAIRY INN", LOCKPORT, N. Y.

cluded to build a dairy inn and milking stalls and started construction in late October, 1931. We had no drawings of a building, and I simply stepped off the size we intended to have it, and the building was designed as we went along with the construction. We made many mistakes which not only increased the cost but delayed the completion of the job, and Randleigh Farm Dairy Inn was not opened until August, 1932, and then only partly equipped.

HISTORY OF RANDLEIGH FARM



SIDE OF RANDLEIGH FARM "DAIRY INN", LOCKPORT, N. Y.



REAR OF RANDLEIGH FARM DAIRY, LOCKPORT, N. Y.

The thought behind the Dairy Inn was to produce pure milk, that is, not letting it come in contact with the human hand nor with the air. This was accomplished by means of the DeLaval Magnetic Milker; to this was attached a specially designed set of vacuum receivers in which the milk was delivered, and out of which it was released into bottles or cans. Five stalls were built which permitted the milking of five cows at a time. We provided facilities for feeding the cows when milking but this was never carried out due to the short time it took to milk.

The Milking Machines

We operate the milker at 15 inches vacuum and one operator easily milks 50 cows per hour. As a matter of fact on one occasion the operator milked 42 cows in 45 minutes as a test.

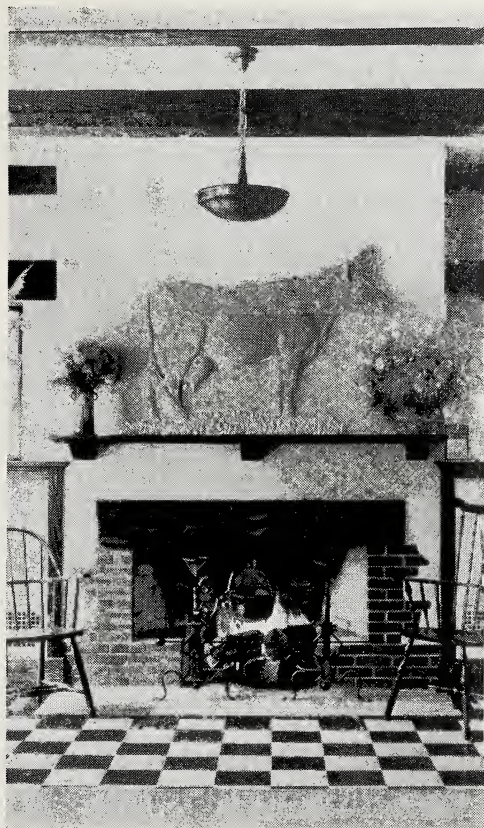
Wilbur Bennett, one of the boys in the test barn, was selected to operate the milking machine in the Dairy Inn. This work was entirely new to him. The results show that he was naturally cut out for this job, and I believe he is the best operator we have ever seen.

These cows are thoroughly milked and while we go through the motion of stripping them, not enough milk is obtained to justify saving it. As a matter of comment: We have had less udder trouble with the milking outfit than when we used to milk by hand, and we thought we had the best milkers available.

The cows stand parallel to the partition between the stalls and the operator's room. They are about 30 inches higher than the operator's floor; this eliminates the necessity of the operator stooping over when attaching the teat cup to the udder and greatly speeds up the operation. This connection is made through a porthole in the partition and these are the only openings in the partition, the rest of it being non-shatterable glass.

The stall gates are controlled by the operator from the operator's room by means of compressed air, simply touching a lever valve.

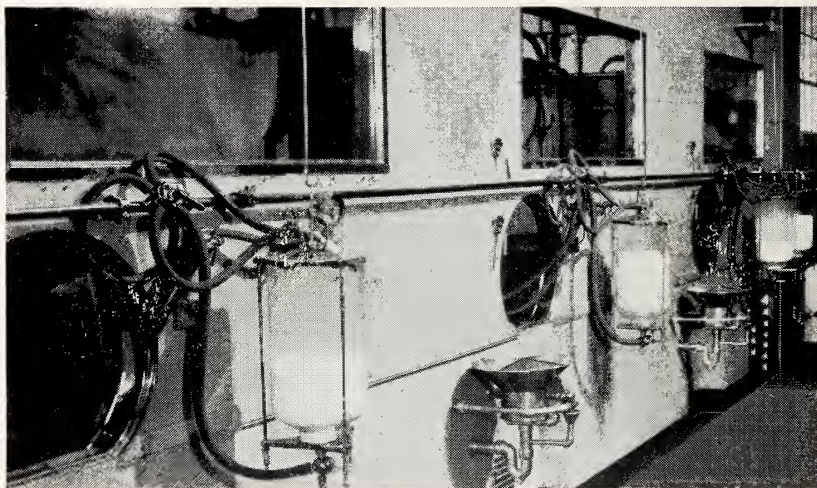
A V-153 Curtis Air Compressor was used to furnish air at the proper pressure. The air cylinders were secured from the Curtis Manufacturing Company, St. Louis, Mo. We are using a $21\frac{1}{2}$ "x24" double acting pendant hoist, used in a horizontal position. The extreme length of the hoist, that is, from the bracket on the wall where the stationary end is attached to the end of the plunger where attached to the gate, is $33\frac{3}{4}$ ". The maximum stroke is 24". The Curtis cylinders were also furnished with detached valves for remote control and also with



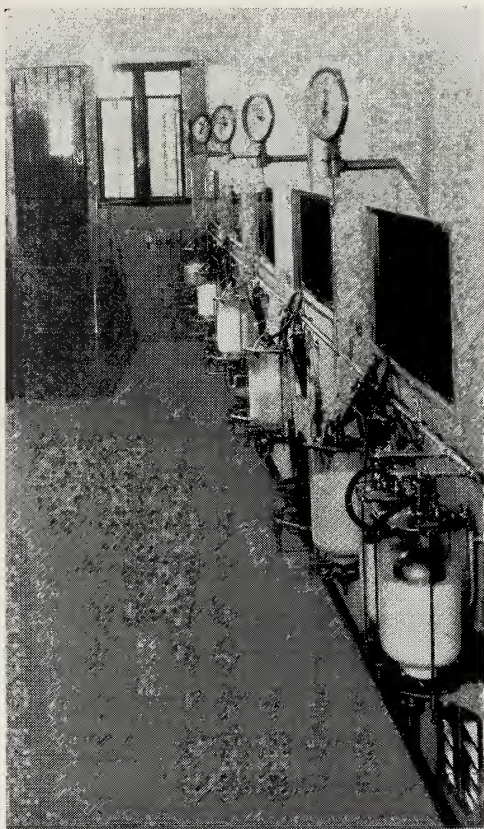
"SOPHIE'S EMILY"
Observation Room, Randleigh Farm Dairy,
Lockport, N. Y.



RANDLEIGH FARM DAIRY INN OBSERVATION ROOM, LOCKPORT, N. Y.



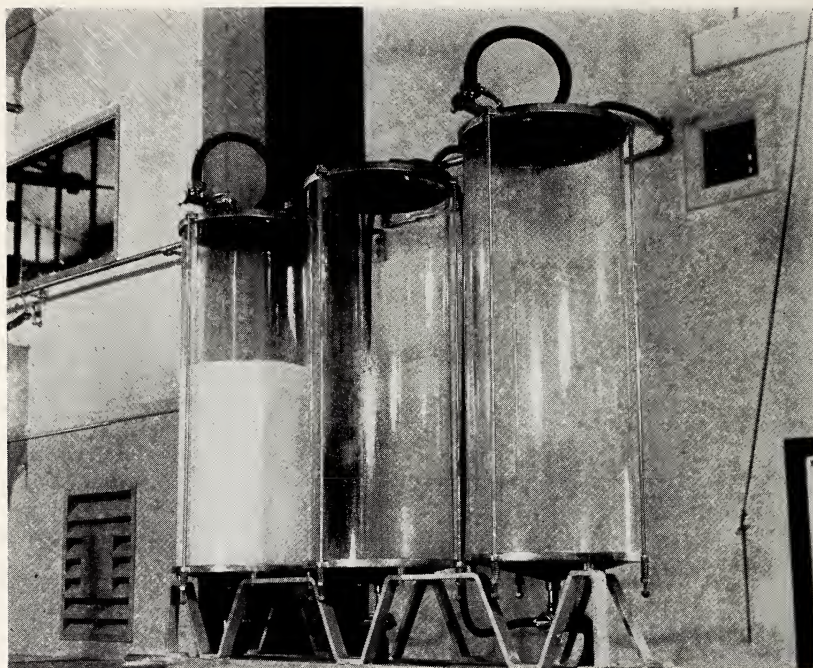
MILKING OPERATION, RANDLEIGH FARM DAIRY, LOCKPORT, N. Y.



MILKING OPERATION ROOM, RANDLEIGH FARM
DAIRY INN, LOCKPORT, N. Y.

automatic cylinder lubricators. The various brackets, valve handles and other fittings were designed and made by us to fit the conditions peculiar to our installation.

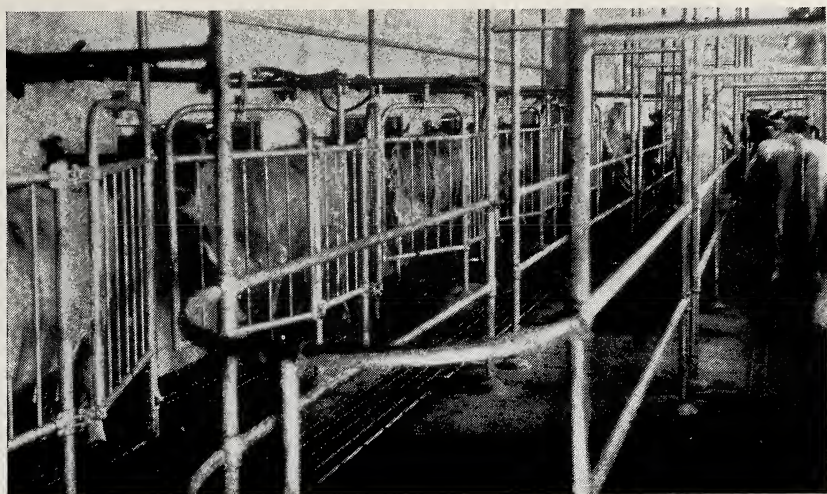
The runway from the barn, 85 feet long, is properly ventilated and contains open sewers with proper gratings in the runway as also in the stalls, pipe railing being installed for the purpose of separating the cows incoming and outgoing. These sewers take care of all the droppings, urine, etc., and are sluiced out by waste washing water after each milking, into a septic tank at the end of the runway, this being 14x14x12 feet deep,



THE MILK STORAGE AND MIXING JARS

the inner compartment taking the solid matter; and after the bacteria have partly liquified, it overflows into the outside compartment to make it still more liquid and then flows outside of the building into a 1000-gallon reinforced concrete tank which is operated by a six-inch iron syphon. This permits the tank to be emptied almost immediately and the liquid is carried down into the pasture where underground tile are installed surrounded by six inches of limestone rock which acts as an irrigating and fertilizing proposition.

On the opposite side of the operator's room is an observation room separated from the operator's room by means of plate glass. This is 54 feet long and has ample space for quite a number of people to sit and observe the milking.



COWS IN MILKING STALLS, RANDLEIGH FARM DAIRY, LOCKPORT, N. Y.

The milk is automatically weighed as it comes from the cow, each cow's milk being kept separate until weighed and sample is taken, when it passes through nickel bronze pipe or glass tubes to the storage glass jars at the end of the room, each with a capacity of 45 gallons. The milk is split into these two jars and is then sucked up into a center jar where it is mixed again. This operation is done for the purpose of getting a uniform milk and it is then bottled direct from the milking jar.

Note that the milking jars are not above the cows, as in many milking parlors, but rather are lower than the cow's udder. This simplifies the milking operation and makes stripping unnecessary.

It is interesting to note here the great difficulty experienced in obtaining these mixing jars. In the first place everybody suggested getting glass lined tanks; and, while these were available from the Faulder Company in Rochester, they did not appeal to me because one could not see whether they were clean, especially in the corners, and besides, the glass lining scaled off. What we wanted was Pyrex glass and after many efforts



THE REFRIGERATORS, SHOWING ONE AIR CONDITIONER

and several trips to Corning we got the Corning Glass Company to make us these jars from designs and patterns made by us. The DeLaval firm furnished the bronze tops and bases made from our designs and patterns.

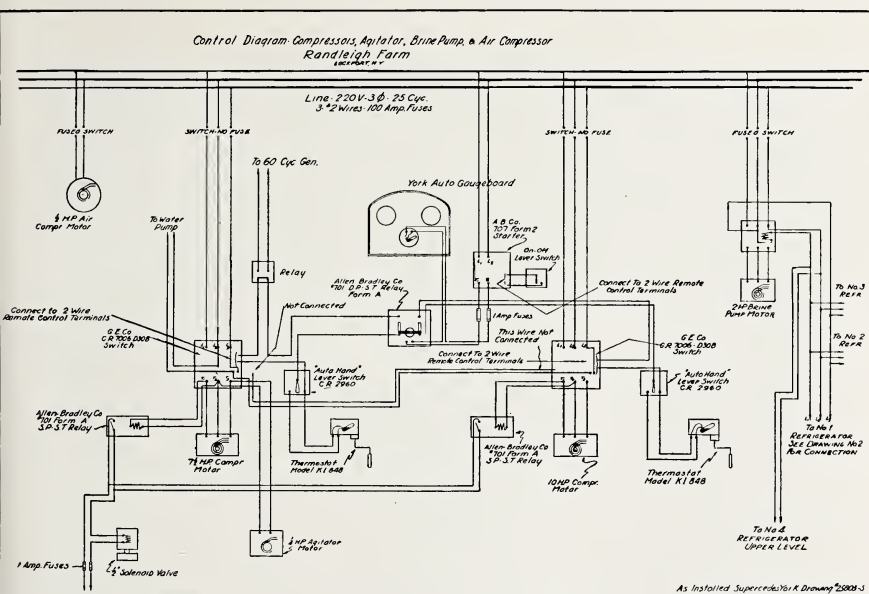
Refrigeration

The refrigeration problem was one which caused us a great deal of trouble and annoyance. The problem as presented was to cool the milk in bottles, it being bottled at the temperature it came from the cow. My inquiry covered the following: To cool 400 quarts of milk, the bottles placed in cases 12 in a case, stacked four high, the milk being 96 degrees F., and this milk to be reduced to 40 degrees in 45 minutes and to 30 degrees in another hour. This inquiry was sent to all refrigerating companies without any interest taken whatsoever in the problem. I obtained the services of Professor Erf, took him to New York

HISTORY OF RANDLEIGH FARM

and together we sold the problem to Carroll Smith, the consulting engineer of the P. & O. Steamship Company and the Florida East Coast Car Ferry Company.

It required more than two weeks of the combined effort of all three of us to get any refrigerating company to even attempt to work out the problem. Eventually we got the York Manufacturing Company, of York, Pa., interested to such an extent that they agreed to furnish the air conditioners and compressors but without any guarantee whatever. I also had the assistance of our engineers in the Florida East Coast Hotel Company who had had a great deal of practical experience with refrigerating boxes of various temperatures. Eventually the system was worked out with the help from all these sources, and the York equipment was installed.



WIRING DIAGRAM SHOWING ONLY A PORTION OF OUR APPARATUS

The whole apparatus is electric motor driven, and we have 28 motors automatically controlled with mercurioïd thermostats. Further, when the temperature outdoors registers 20 degrees F. or lower, all the machines shut down except the individual fans for each box which continue to operate, taking the air from the outside through the box and discharging it again to atmospheric pressure. These fans circulate the air around the bottles at a rate of 2000 cubic feet per minute. Our calculations indicated in order to meet the requirements proposed, it would be necessary to circulate the brine in the air conditioners at about four or five degrees F. above zero. However, we learned from experience that it was necessary to operate it only about 15 to 16 degrees F. for the reason that the air conditioners contained 500 lineal feet of three-quarter-inch pipe; and even with the thermostat completely cutting off the circulation of the brine, there was enough brine in the coils to carry the temperature of the milk down below freezing.

The air has been drawn up through the brine coils which contain brine at a temperature of about 16 degrees above zero. This cools the milk rapidly with all the nutritional factors as liberated by the cow intact. The only difference between this milk and the milk as it comes directly from the cow is the factor of temperature, which also is a factor in nutrition and is undeniably lost but can partly be replaced.

We have three boxes which we operate for cooling milk, also one box containing a brine tank for bulk milk and ice making, with a capacity of 400 pounds per day. Also we have one large box for storage of dairy products which is controlled at about 38 degrees. We have a freezing room for the purpose of freezing fruits which we carry at between 10 and 12 degrees F. above zero. We have also an ice cream storage compartment that is carried at about the same temperature. Then we have a room with ammonia direct expansion aluminum plates as shelves and this is carried at about 20 degrees below zero. This is for

hardening purposes and quick freezing. By all means put in plenty of insulation. Two inches more than is generally recommended by refrigerator companies will prove economical.

The economical, efficient and satisfactory operation of this refrigerating plant is beyond words. Burgess Lee, engineer at the Western Block Company, was most helpful in installing all our equipment.

Sterilizing Equipment

The sterilizer, which has four compartments each sufficient to carry 400 bottles in cases, was constructed under one end of the runway of reinforced concrete insulated with hair felt. By using steam through a heater and circulating hot air through all the sterilizers each one independently it is possible to obtain a



THE STERILIZER

temperature of 250 degrees F. The return hot air is put through a condenser which eliminates all the moisture and, therefore, the bottles come out absolutely dry. The bottles, of course, previously have been washed inside and out thoroughly with rain water or well water softened by means of a Permutit system and then chlorinated before being put into the sterilizer. We have rain water storage capacity of 30,000 gallons.

The waste heat from the sterilizer is used to heat the floor and gutters of the runway as also the stalls, provision being made so as to warm up the udder in cold weather, as we feel a little heat on the udder makes the cow let down the milk more freely.

A number of experiments were made during the summer of 1932 as to what effect inert gases had on the milk. These experiments were carried out in connection with hydrogen, nitrogen and CO₂ gas. It was determined that nitrogen had less effect on the flavor than any of the other inert gases and by reducing the amount of oxygen present made the milk keep a much longer time under adverse conditions. The reason for these experiments was the thought of admitting an inert gas into the milking system when the milk went from the individual jars to the storage jars and also with the desire to admit nitrogen into the bottle before filling with milk.

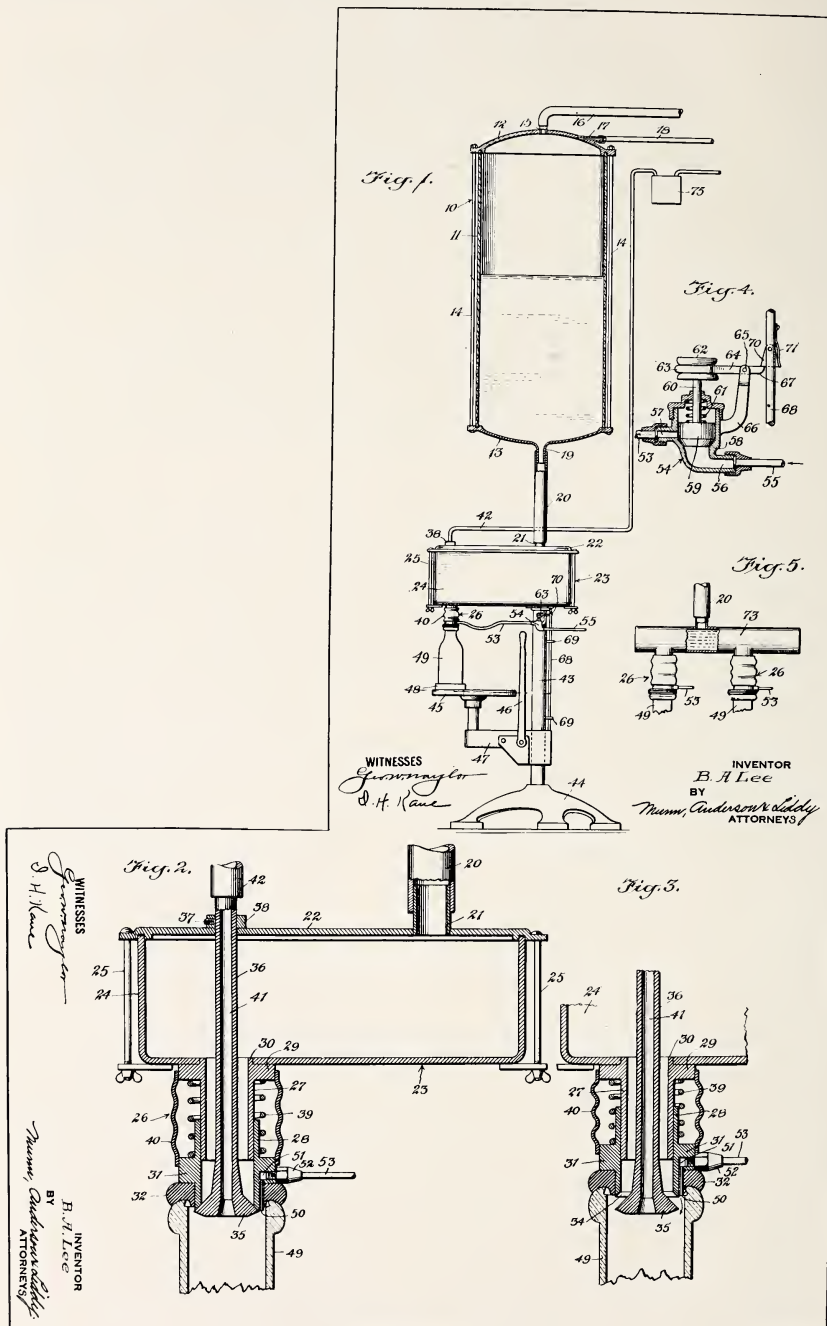
During the summer of 1933 Dr. Demorest, of Ohio State University, made some exhaustive tests on the gases in the udder of a cow, with the result that we determined to use both nitrogen and CO₂, attempting to reach balanced milk such as actually was in the cow's udder. Further, the CO₂ would tend to keep a larger percentage of calcium in solution and produce a softer curd milk which is more easily digested. The analysis shows as the milk comes from the udder the volume of gases it contains is 27 to 30 percent carbon dioxide and 73 percent nitrogen. The foam in the milk in the jar runs from 18.1 up to 20 percent carbon dioxide and the nitrogen varies from 75 to 80 percent.

There is also a combination of volatile oils the structure of which is exceedingly complicated. There is no hydrogen in the udder but it seems to be present in the foam in the jar. Therefore, it seems there is a loss of from six to nine percent which is drawn out of the milk and will have to be replaced somewhere. Dr. Demorest's contention was that it would take little gas to make up what was lost.

We have after many years of intense experimenting succeeded in designing a valve for an automatic bottling machine which will work under 15 inches vacuum. We are constructing a machine and hope to have it in operation soon. Patent has been applied for on this valve.

This will complete our system of taking the milk from the udder of the cow, placing it in a bottle, and sealing it without coming in contact with air. It will also retain in the bottle the gases which are present in the udder of the cow. What gases may be lost in transferring from one glass container to another will be replaced by the addition of a gas composed of equal parts of nitrogen and carbon dioxide. This was our original objective when we constructed the Dairy Inn more than four years ago.

The drawings and description of this valve follow:



AUTOMATIC BOTTLE FILLER VALVE

It is an object of the invention to provide improved apparatus of the foregoing character for bottling raw milk in substantially the same condition as in the udder of the cow. To do this the milk must be kept from any prolonged contact with the air. Heretofore, milk has been taken from the cow by means of milking machines and has been conducted through sealed tubes to a storage tank without any substantial contact with air. However, in the apparatus heretofore used, when individual containers or bottles were filled with the milk from the storage tank, the milk came into contact with the air, resulting in certain changes in the condition of the milk. The present invention overcomes these difficulties by providing an apparatus which fills individual bottles or containers with milk from the storage tank without exposing the milk to air. The apparatus may also be used in filling containers or bottles with other fluids, especially where it is desired to prevent the fluid from coming into contact with air.

A further object is to provide an improved apparatus for filling containers and the like which operates in a single improved manner, first evacuating the container and then introducing the new fluid, all in a single, relatively simple operation. Another object is to provide a milk bottle-filling mechanism for introducing inert gas, preferably carbon dioxide, into the top of the bottle immediately after it has been filled, thereby aiding to preserve the milk in its original condition and also helping to break the engagement between the bottle and the filling apparatus.

For a fuller understanding of the invention, reference should be had to the accompanying drawings, in which

Figure 1 is an elevation in section of a bottle-filling apparatus embodying my invention, showing it in association with one form of fluid tank, stand and shiftable bottle table.

Figure 2 is an elevation in section showing the nozzle portion of my improved bottle-filling apparatus with the valve in closed position and having a milk bottle in sealing engagement therewith.

Figure 3 is an elevation in section somewhat similar to Figure 2, but showing the valve in open position so as to permit the milk or other fluid to enter the bottle.

Figure 4 is a sectional elevation of the valve for controlling the flow of carbon dioxide or other inert gas into the top of the container after it has been filled.

Figure 5 shows a modification of my invention so as to permit several containers to be filled simultaneously.

(This valve was developed by Burgess Lee in cooperation with Professor Oscar Erf.)

We could inject gas into the tube where the milk flows into the jar provided we had a reduced pressure valve on the two tanks. The addition of a little carbon dioxide prevents the precipitation of the calcium salts in the milk and in addition the nitrogen prevents the oxidation of milk. Hence, by maintaining a 50 percent carbon dioxide and 50 percent nitrogen gas, we would have it quite accurately balanced.

These experiments are still being investigated and we expect to have some interesting results therefrom.

The Dairy Inn was constructed much more elaborately than would be necessary for practical purposes. The reason for this was that it was novel, and we thought an attractive, impressive building would be far-reaching on the people who came to see our milking process. We have been encouraged by the comments made by visitors, not only on the way we handle the milk and the kind of milk produced but also on the building and its arrangements.

Our milk is plated frequently to determine the bacteria (kind and number), and we have in use a complete outfit for this purpose, namely "Official Breed Microscopic Method, E-Z Micro Test," made by Lacteal Analytical Laboratories, Inc., Buffalo, N. Y.

CHAPTER IV.—FEEDS

PREVIOUS to July 1, 1921, a commercial ready-mixed ration was used. After that date was fed a mixture of ground oats, bran, gluten and cornmeal with the proportions varied to meet the apparent needs of the individual animal, but usually equal part by weight. Leaves from second cutting alfalfa were added, and the feed was then placed in water-tight individual bowls. Hot water was added and the mixture stirred well, after which it was covered and allowed to steam until feeding time (about two hours after being moistened). When ready to feed, wet beet pulp was added, except during the winter months when home-grown mangel-wurzel beets were available. This method was used until the fall of 1930, when the following was added:

COMPLEX MINERAL RATION

Pounds

- 50 Calcium Phosphate or Raw Bone Feeding Meal (odorless and with 24 percent Protein)
- 25 Calcium Carbonate
- 25 Iodine Feed (Dulse)
- 16 Charcoal
- 6 Blood Meal (odorless)
- 10 Bicarbonate of Soda
- 1 Iron Oxide
- 1 Manganese Oxide
- 1 Potassium Carbonate
- 2 Calcium-Chloride

Ounces

- 1 Sulphur Praecipitatum
- 4 Calcium Iodide
- 2 Black Sulphate of Antimony
- 4 Iron Sulphate
- 2 Copper Sulphate
- 2 Juniper Berries
- 2 Fenugreek
- 2 Anise Seed
- 2 Caraway Seed
- $\frac{1}{4}$ Aloes
- $\frac{1}{8}$ White Arsenic

One week each month add two pounds of potassium chloride to ration above. If laxative is needed add 18 pounds of Glauber's salts. For intensifying skin gland activity add four

ounces of jaborandi. Mixture should be ground fine, 400 mesh if possible. Twenty-five pounds may be added to 2000 pounds of feed.

Hydrolized feed was introduced in the early spring of 1929. Randleigh Farm started sprouting grain (oats) in galvanized trays 2½ inches deep, placed in racks in the boiler room of the milk house. It was first sprouted to two inches length, then chopped up and fed to the bulls. Professor Erf expanded on our use of hydrolized feeds beginning in August, 1930, and this system of feeding has been constantly in use up to the present time.

In preparation of this feed nearly equal parts (by weight) of clover, alfalfa and timothy are used. After these hays are ground in a hammer mill, using a screen with one-inch mesh, one day's supply of the three kinds is mixed and to this is added the required amounts of beet pulp, cornmeal, mineral and salt. The sprouted grains described elsewhere are also added at this time. This mixture is now divided into three equal parts, one for each feed, and placed in especially built wooden tanks with tight covers. These tanks are four feet long, three feet wide and 30 inches deep and are equipped with castors in order that they may be readily moved when necessary. Eight hours previous to feeding the mixture is thoroughly saturated with water at about 140 degrees F., the cover placed on and it is allowed to steam until fed. At feeding time it is placed in individual containers, and the balance of the ration consisting of gluten, bran, oilmeal and ground oats is added.

Note that after 15 years our grain mixture still contains the original four ingredients consisting of bran, ground oats, gluten and cornmeal. Since feeding hydrolized feed it has been possible to include oilmeal in the ration as a part of the mixture if fed dry whereas it was not practical to do this when the entire mixture was wet before feeding.

Grain Feeds (Standard Formula)

COWS

A mixture of gluten, ground oats, bran and cornmeal—average equal parts by weight—vary according to individual animal, based on physical condition, amount of milk being produced, etc.

Cows that are expected to freshen should have a small amount of liver, about one-fourth ounce per cow per day, and also five grams of iron ammonium citrate. This is in addition to the six ounces of iron ammonium citrate and two extra grains of iodine and in some instances more calcium which they get from the mineral ration. To get iron into the cow you must use liver meal; five grams equal 120 grains. This is the only way we know of getting iron into the cow.

Begin feeding as above 30 to 40 days before calving, and then five or six days before, double the dose of iron ammonium citrate. Use the powder and not the flake of iron ammonium citrate. This can be purchased from Merck Chemical Company, Rahway, N. J.

CALVES

A mixture of ground oats, bran and cornmeal—equal parts by weight—to this add one-half part of linseed oilmeal and then add one percent bonemeal and one percent salt.

Feed whole milk for four or five weeks, gradually tapering off to skim-milk. Add to the feeds above our regular mineral ration.

Feed germ of wheat to calves one-fourth to one-half pound per calf per day, both young and old; the ration should be about 15 percent to 17 percent of germ wheat to total pounds of grain you give to the calves.

If heifers are well developed, when 10 months to one year old, let them rough it all summer in a good pasture with some

shade and with no further feeding. If undersize or younger, we pasture them as above indicated and, in addition, we bring them into the barns at night and feed them grain.

In handling calves kindness and patience are necessary; no rough treatment should be permitted. They should be haltered and led when about three to five months old, and coaxed, not driven.

The cow is a creature of habit. Therefore, it is imperative that she be fed and milked exactly at the same time each day. It is necessary that cows producing forty pounds or over be milked at least three times each 24 hours, otherwise you are liable to have considerable udder trouble.

These high producing cows are usually of a nervous temperament and they should be handled easily, carefully and without any noise or commotion. Never hurry a cow and under no circumstances let any one strike or abuse her.

We have used the radio in the barns with good results—not that the animals like music, but it gets them accustomed to noises and talking. They are generally milked when only the milkers are present and we have found that when visitors or the tester are present they usually converse which distracts the cow and reduces her yield while they become accustomed to the radio and the results as above indicated are minimized.

Our desire is to produce cows of excellent quality, good producers, with hardy constitutions and gentle nature. This last characteristic is most important, for the cow which becomes easily excited drops in production from almost any slight cause and the bull which is not easily handled is a constant menace. Proper handling produces gentleness. They should never be driven, always led and never subjected to rough treatment or any excitement.

Farm-grown Feeds

The farm is thoroughly equipped for growing grasses, hays (alfalfa, clover, timothy, bluegrass), grains and sugarbeets. We believe it is possible for us to raise sufficient feed for our herd of approximately 165 head (provided we can develop some satisfactory method of curing our grasses) with the exception of gluten, cornmeal, hominy, oilmeal, bran and beet pulp. These six items we are forced to purchase in the open market.

By the construction of a storage grain bin (wooden construction, rat-proof) adjacent to the barns, with a capacity of about eight carloads, we are able to purchase a year's supply of the items above at certain times of the year when the price is right. The gluten is usually purchased in the late spring and beet pulp in the fall.

We keep regularly three teams of heavy draft horses, three tractors and a complete line of farm tools and trucks.

MINERAL RATION

(Revised January 1, 1933)

35 pounds Calcium Phosphate. (This must be the raw bonemeal which should not contain less than 24% protein. Must include Medulla, or Bone Marrow!).

15 pounds Dicalcium Phosphate.

13 pounds Calcium Carbonate, or finely ground limestone. (This must be fine enough that at least 90% of it will go through a 400-mesh screen. Otherwise, the lime is not available. Limestone shall not contain more than 20% of Magnesium).

10 pounds	Sodium Bicarbonate	½ ounces	Bismuth Subnitrate
12 "	Charcoal	½ "	Strontium Lactate
8 "	Odorless Blood Meal	¼ "	Sodium Bromide
4 "	Calcium Chloride	¼ "	Zinc Oxide
2 "	Magnesium Sulphate	½ "	Stannic Chloride
1 "	Potassium Carbonate	½ "	Stannum
4 "	Magnesium Chloride	¼ "	Calcium Fluoride
12 ounces	Potassium Aluminum Sulphate	14 "	Jaborandi
4 "	Potassium Iodide	10 "	Black Haw
2 "	Copper Sulphate	2 "	Juniper Berries
6 "	Iron Ammonium Citrate	2 "	Fenugreek
4 "	Manganese Phosphate	2 "	Anise Seed
4 "	Magnesium Silicate	2 "	Caraway Seed
1 "	Sulphur	½ "	Cinchoanin

Feed twenty pounds to one ton of feed.

MINERAL RATION

(Revised January 1, 1937)

35 pounds Calcium Phosphate. (This must be the raw bonemeal which should not contain less than 24% protein. Must include Medulla, or Bone Marrow).			
15 pounds Dicalcium Phosphate.			
11 pounds Calcium Carbonate, or finely ground limestone. (This must be fine enough that at least 90% of it will go through a 400-mesh screen. Otherwise, the lime is not available. Limestone shall not contain more than 20% of Magnesium).			
10 pounds	Sodium Bicarbonate	$\frac{1}{2}$ ounces	Bismuth Subnitrate
12 "	Charcoal	$\frac{1}{2}$ "	Strontium Lactate
8 "	Odorless Blood Meal	$\frac{1}{4}$ "	Sodium Bromide
4 "	Calcium Chloride	$\frac{1}{4}$ "	Zinc Oxide
2 "	Mono-calcium Phosphate	$\frac{1}{2}$ "	Stannic Chloride
2 "	Magnesium Sulphate	$\frac{1}{2}$ "	Stannum
1 "	Potassium Carbonate	$\frac{1}{8}$ "	Calcium Fluoride
4 "	Magnesium Chloride	14 "	Jaborandi
12 ounces	Potassium Aluminum Sulphate	10 "	Black Haw
4 "	Potassium Iodide	2 "	Juniper Berries
2 "	Copper Sulphate	2 "	Fenugreek
6 "	Iron Ammonium Citrate	2 "	Anise Seed
4 "	Manganese Phosphate	$\frac{1}{2}$ "	Cinchoanin
1 "	Sulphur	$\frac{1}{4}$ "	Cobalt Chloride

Feed twenty pounds to one ton of feed.

Minerals are all inter-related. Infection disturbs mineral balance. Calcium can not be taken into the system unless there is a phosphorus medium and, further, calcium and phosphorus are more easily taken into the system when there is a magnesium, iodine, manganese balance. Potassium may partly be radioactive. Arthritis is due to the unbalancing of the mineral complex, usually caused in cows by the ovary being involved. If the minerals are unbalanced, the cow may run into disease. Magnesium and phosphate are quickly exhausted even in a new country.

Iodine stimulates the thyroid gland and indirectly regulates the calcium intake. It also assists in oxidation. Grass will take up about $1\frac{1}{2}$ to 3 pounds of iodine to an acre. Copious rains increase the take-up greatly.

Fowler's solution is an excellent tonic and a remarkable stimulant to both skin and udder. A conservative dosage follows: 20 drops per day per cow for two days in every month, or $\frac{1}{8}$ ounce of white arsenic added to the ration may be substituted.

For a laxative condition add 18 ounces Glauber's salts per day to the ration. This formula is being used by us at the present time.

This mineral ration can be purchased from J. O. Rignel Company, Inc., Lockport, N. Y., who has the formula and is furnishing it to Randleigh Farm.

Mineral Metabolism

I quote from a letter sent me by Professor Erf, explaining the reasons for this mineral formula:

"I am sending you the new mineral ration and an explanation of some of the effects it may have on your cows. Since the subject is such an extensive one I will limit my discussion to the general effects.

"Cattle need, as do all animals, a complex mineral intake for normal existence. Low-producing cattle obtain sufficient quantities for their needs from forages and grasses. However, in high-producing cattle mineral deficiencies frequently occur, because the mineral stores are depleted in proportion to the amount of milk that the cow produces. The degree of exhaustion is determined by clinical experience and laboratory procedures. Laboratory findings, such as red cell count, white cell count, hemoglobin content, blood chemistries (as blood iron, phosphorus, iodine and calcium), urine and manure examinations and milk analyses are helpful for determining the immediate status of the cow and for health records but clinical judgment and experience is, of course, the valuable basis for a rapid and accurate diagnosis.

"We do not know all the intricacies and details of mineral metabolism but we know from experience that grasses and forages supply most of the calcium and most of the other minerals to cattle. We are fully aware, however, that the addition of inorganic minerals in the ration is a distinct value to high-producing cattle. If fed in large quantities upsets in the digestive system occur. Minerals that are incorporated with the growing plant are the least irritating.

"The individuality of cows vary greatly and different combinations of minerals are necessary to combat the various disorders that arise. Cows fed to maximum capacity become very sensitive to slight variations or changes in feeds. Low-producing cows are less sensitive to the crude natural influences and do not exhibit physiological changes readily.

"Some of the symptoms that indicate mineral disturbances are: edema (an allergic state), lusterless eyes, low milk production, sluggishness, loss of appetite, thickening of the skin, thickening of rib periosteum, etc.

"The associated factors of minerals, such as vitamins, enzymes, hormones and other unknown nutritional influences are most impor-

tant. Young, green, well-fertilized grasses provide these in abundance, but during the winter months they must be supplied in sufficient quantities, and this is done by feeding green dried hays and germinated grain. Dried green hays have many of these nutritional assets while brown hays have practically none. The artificially low-temperature dried hays have a content approaching the fresh green hay. Germinated grains also have many of these associated factors since they were responsible for a noticeable enhancement of mineral metabolism. Later we discovered that by cutting and moistening hays the minerals were rendered more soluble. Still more effective in assimilability of minerals was the mixing and heating of the cut hays and sprouted grains to a temperature of 135 degrees. This prevented undesirable fermentations and mold growth, and aided by catalysis enzyme activity such as the beginning conversion of starches into sugars. Heating does, however, destroy some of the vitamins but this was overcome by feeding additional raw sprouted grains separately. Too much of this raw sprouted grain caused diarrhea.

"When the grain is sprouted in daylight or under ultraviolet light chlorophyll is formed which is easily converted into the essential blood builder, hematin. This combines with the iron furnished in the ration to form hemoglobin. Thus through hydrolysis, enzyme action, sprouting, raying and inorganic mineral additions we practically make artificial grass, at least chlorophyll, xanthophyll, and carotin are present.

"We now are modifying the old mineral ration by feeding more calcium diphosphate and bonemeal and less ground limestone because they are more readily available to the body. In this ration we have several forms of calcium and phosphorus. So the cow, irrespective of her acid-alkaline balance, will be amply supplied with these minerals. Likewise the magnesium in this ration has various forms, as a sulphate, as a chloride or as a carbonate. Magnesium is an essential factor in milk secretion. As is known, sodium as a nerve irritant, potassium and bromine as a depressor and calcium and strontium as a stabilizer play valuable roles in animal muscle unification. Sodium bicarbonate as a neutralizer aids greatly in soothing the disturbing waste acids. The inter-relationship of minerals is illustrated when one realizes that iodine is essential to the thyroid gland which influences the parathyroid gland, which controls calcium metabolism. Copper is an essential structural agent of blood and blood forming elements. Iron in available forms, such as iron ammonia citrate, is the basis of the oxygen carrying hemoglobin. Manganese phosphate is a functional unit utilized by the spleen and liver. Calcium fluorides are closely associated in bone and tooth development. Sulphur is found in many proteins and plays an active part in muscle and milk proteins. Bismuth may be a significant help as a bacteriological agent. Zinc is found in significant quantities in endocrines and may be a stimulant to them. Even tin is utilized by the skin. Alum or potassium aluminum sulphate has fungicidal prop-

erties in small quantities. Carbon, as charcoal, has valuable absorptive power, a deterrent of gas formation. Odorless blood meal supplies more soluble proteins and amino acids not available in most feeds. Jaborandi is known as a stimulator of the sweating mechanism and mammary glands. Juniper berries, anise seed and caraway seed are tonics and stimulants to intestines and kidneys. Black haw is a beneficial uterine stimulant. Cinchoanin is a helpful bitter tone. There are other roots, herbs and seeds that have selective values which we are now investigating.

"The results of feeding these ingredients over a number of years have convinced us of their usefulness in your herd by its remarkable milk and reproductive records.

"A doctor from a large commercial firm in Detroit came to Ohio some years ago to inquire whether milk secretion is similar to sweating, and, if so, how a proper mineral balance might be maintained. We explained to him that the processes are much the same, and that through the cycle of evolution animals developed mammary glands from what originally were sweat pores.

"He had asked, 'How do you keep up the mineral substances in a cow? We have thousands of workers in the intense heat near furnaces and the laborers sweat profusely. They lose so much mineral by sweating that about 12 percent must be temporarily hospitalized on warm days.' After he became informed of approximate amounts and correlation of the minerals, he accepted the same mineral elements given to cows and later had them compressed into pills. These were then taken by the laborers whenever they drank water. After this method was instituted less than one percent needed further hospitalization.

"Years ago cows had this same loss of mineral balance, and it was evidenced in quivering of the muscles. This problem was worked out in Switzerland. In one experiment with a dog a rubber tube was inserted at the top of the abdomen, and with distilled water the salts were washed out through an orifice at the bottom. The dog went into a state of coma, but revived when given a solution of salt, calcium, phosphorus, magnesium and potassium, with a minute quantity of iron. This was an early demonstration to prove that minerals are catalysts to foods. We now know it is possible and beneficial to introduce a complex saline solution into the blood stream even when the patient is in an extremely weakened condition.

"There are no other practical compounds other than iron and cobalt chloride as far as we know that will increase the hemoglobin of the blood."

Effect of Iodine

About 12 years ago we commenced feeding carrots, the idea being that their iodine content would be beneficial to the cows. As this did not seem to injure them and it carried a larger percentage of iodine than any other vegetable, we went to kelp, dulse or seaweed, and fed that for a winter. Then we changed to fish meal, or halibut, which has a larger percentage, and during the winter of 1932 we started with inorganic iodine in the form of potassium iodide. A seven and a half grain tablet contained five and a quarter grains of free iodine.

We started feeding a small percentage and increased the amount until we got up to one and a half grains of free iodine per cow per day, and even this amount seemed to be of benefit to the animals physically and we could see no ill effects. However, we found by actual test with the particular ration fed at that time approximately one and three-fourths of a grain seemed to saturate most cows, and any amount above that would check the appetite, and a considerable amount was found in the blood and was gradually eliminated in the feces and urine.

We further found as we increased the percentage of iodine fed the animals, the iodine content of the milk increased, and we were able to obtain approximately 64 gamma, or micrograms, which is one one-thousandth of a milligram of iodine per quart of milk. I understand that the average child requires as a minimum only 50 gamma per day. The average milk in this territory contains about 4 to 12 gamma per quart. For human adults the amount above is in addition to the usual iodine in the average table meal in the Lake region which contains little iodine. Human needs for iodine in Florida and the South may be but 14 gamma in food since the air contains volatile iodine which is inhaled. In the region of the Great Lakes however, the human needs for iodine are greater to maintain normal thyroid activity. During 1934 we fed as much as two and three-quarter

grains per cow per day without any ill effects. Whether it will be of advantage will be determined later.

This work was carried out in cooperation with Dr. George M. Curtis and Dr. Francis Phillips, both of Columbus, Ohio. Dr. Curtis is professor of surgical research at Ohio State University. He has long been interested in iodine, particularly in its relation to goiter and to thyroid functions. He spent three years studying goiter in Switzerland and was, for a number of years, professor of surgery at the University of Chicago. Dr. Phillips is research assistant to Dr. Curtis. They have recently developed an accurate method of determining the iodine content of blood, milk and urine.

We believe iodine does seem to increase the milk flow of high-producing cows. It does increase the percentage of fat of some cows. This apparently depends upon the nature of the cow as well as upon the relation of iodine to other mineral and organic constituents fed. Cows bordering upon hypothyroidism seem to be decidedly improved by feeding iodine. This probably is due to the more balanced mineral condition of the body. It will build up certain cows and it has built up, in particular, it seems to us, a greater resistance of cows to *B. abortus*. As a result the reproductive organs are brought back to more nearly normal. We have observed this for a number of years.

We are convinced that organic iodine is essentially a better form of iodine to feed as it does not check the appetite of the cow if fed in large quantities, although in our experiments we have fed iodine moderately inorganically as well as organically with good results.

These experiments, while incomplete, are far-reaching and effective and may be highly beneficial to the human race.

CHAPTER V.

MALTING OR GERMINATING GRAINS

IN FEEDING minerals we have found it highly desirable to add malt or sprouted grains to the daily diet, and for a number of years we used Fleischmann's yeast, about one percent of malt per day per cow. As this percentage increased, at the present time being 13 percent of malt per cow per day (with the expectation of feeding 16 percent during the winter), we concluded it was necessary for us to produce our own malt. Hence, Professor Erf designed and we constructed sprouting frames which hold about 38 pounds of grain and can be controlled absolutely by regulating the temperature and the humidity. Therefore, we can have fresh malt every day. We are able to sprout any kind of grain. This sprouted grain increases the vitamin B complex in the feed ration. Germinating also intensifies the other vitamins, particularly C and E, and develops enzymes to assist digestion and vitamins, auxines and plant hormones which have an effect on the reproductive glands. These associate factors are necessary for mineral metabolism; otherwise some of these minerals are not properly taken into the system. Vitamin C has been found to be important as a non-oxidizing agent of the milk produced by the cow. The effect of C is carried through the cow to a great extent. E, in combination with the pellagra B, is a vitamin which acts as a factor in reproduction.

These grains when introduced into the rations have a desirable effect on the mesentery, the mammary besides the reproductive glands. This proves beneficial, in our judgment, and we have given this system to quite a number of other breeders of cattle.

New Cabinet For Sprouting Grains

Our new cabinet for sprouting grains consists of three parts: A stationary frame supporting the trays of grain, a movable

frame supporting the water trays, and an insulated cabinet enclosing the frames. The stationary grain tray is made of four light angle-iron corner posts, fastened together with flat braces to form a hollow rectangular framework about 42 inches high. Three side rails or guides are fastened on each side, extending from front to back, one above the other, about 12 inches apart. These rails receive shallow trays, $16\frac{3}{4}$ inches wide, 30 inches long and one inch deep, which slide in and out similar to a drawer. The bottom is composed of one-eighth inch mesh screen.

A second frame of similar construction is for water trays, except that these are not removable from the frame but fastened in place. This frame is slightly wider and longer than the grain frame and completely surrounds it, one frame inside the other. The water trays rest on braces on the front and back of the outside frame and are just beneath the grain trays, so arranged, when both frames are resting on the floor, that the top of the water trays is level with the bottom of the grain trays. The water trays are enough wider than the grain trays to allow them to nest one inside the other. A cabinet built of two thicknesses of insulating board with a two-inch air space encloses the frames with a deep door in front of each set of trays. On top of the cabinet there is a hand lever extending from the center of the cabinet roof toward the front, with the rear end of the lever connected by a rod to the top center of the frame carrying the water trays. By means of this lever the frame can be raised until the grain tray is nested down into the water tray, and latched in this position.

A vertical pipe with a funnel top is placed at the rear of the cabinet with three horizontal filler spouts extending through the wall of the cabinet, one over each water tray.

Temporarily the trays will be filled with water from a can placed on top of the cabinet having a faucet reaching over the funnel of the standing pipe. The water runs down the pipe, through the filler spouts and into the water trays. Each water

tray has a drain connected by a short length of flexible hose to a second vertical pipe to carry off the water after each grain immersion. Suitable valves are in these filling and drain lines to control the water.

The procedure is as follows: Each grain tray, with one-half to three-fourths inches of grain, is pushed through the door, on to the rails, and slid back into position directly over the water tray. The doors are then closed and left closed until the grain sprouting is finished, to keep the CO₂ given off from the grain, from escaping. The water trays are then filled from the water can at the top, the water being of proper temperature, approximately 95 degrees F. A peep hole in the cabinet is used to watch the water levels in the trays, each tray having one to one and one-fourth inches of water.

By means of the lever on top of the cabinet, the outer frame holding the water trays is raised, bringing the tray up around the grain tray, until each grain tray rests on the bottom of its respective water tray, the bottoms of the grain trays being perforated to let the water flood the grain. After 30 minutes the water trays will be lowered and the water drained out. If there is any evidence of mold, the water trays can be flushed out with clear warm water.

A pan of water is kept in the bottom of the cabinet to keep the air moist and the temperature of the cabinet kept at the desired point, either by heating this water or by heating the air in the cabinet and controlling it thermostatically. Probably a lighted lamp inside will be the simplest means of providing heat. The germinated grain should be kept at about 90 degrees F. The electric elements should control between 90 and 92 degrees F.

Germinated grain is nothing more than young grass. Corn sprouted contains pro-hormones, which help the cow to produce a fully developed calf. Barley is somewhat deficient in this pro-hormone, but does contain an element to make the cow

fleshen and improves the milk production. The high-producing cow requires besides minerals and vitamins, hormones, auxines, enzymes and special proteins. Germinated grains give many of these things in proper proportion and also have a tendency to protect the body from diseases.

Germinated Grain

Long sprouts (three to four inches) produce higher vitamin C in larger amounts. When you have mold spores present (as they usually are in a barn) the longer period of sprouting allows molds to develop and these in turn produce an odor, and the cows do not like such feed. We make a pro-insulin by sprouting grain, which is of great benefit to the cow. Short sprouts (three-fourths to one inch) produce vitamin B complex, which is the milk-producing vitamin. We germinate grain to thicken the cell membranes and intensify glandular secretion. Malt (the extract of germinated grains) with minerals is used where human mothers are not lactating sufficiently. Germinated grains will tend to prevent winter milk of bad odors.

CHAPTER VI.

TESTS ON PASTURES

THE minerals used in connection with our feeding program have been primarily calcium, phosphorus, magnesium, iron, iodine and manganese. We have had favorable results from the use of these elements in our mineral ration and certainly have improved the physical condition of the animals by the inorganic minerals.

Our effort now is to do the same thing organically, for the cow must assimilate some minerals almost entirely through grasses and hay and a small amount through grains. We feed seven separate pastures, containing several acres each, with the minerals needed and try to grow grass which the cows will relish and at the same time give them the proper amount of minerals from the soil through the plant.

These experiments have been worked out with the assistance of Professor Erf. We had purchased all the ingredients necessary and planned to carry out these tests during the year 1933, but the dry summer made the results unsatisfactory and the test was repeated. Samples of soil from each of the pastures were taken and thoroughly analyzed in order to arrive at a basis as to what minerals to use. Where liming was necessary or manure desirable this was applied during the fall. Only one pasture was plowed up so as to vary the experiment.

DETAILS OF TEST

Plot No. 1	350	pounds	Superphosphate
	150	"	Potash
	<hr/>		
	500	"	per acre, size 2½ acres
Plot No. 2	100	pounds	Nitrate of Soda
	350	"	Superphosphate
	150	"	Potash
	<hr/>		
	600	"	per acre, size 2½ acres
Plot No. 3	100	pounds	Ammo Phosphate per acre, size 2½ acres
Plot No. 4	400	pounds	Superphosphate per acre, size 2½ acres

H I S T O R Y O F R A N D L E I G H F A R M

Plot No. 5	350	pounds	Superphosphate
	150	"	Potash
	100	"	Ammonium Sulphate
	600	"	per acre, size $7\frac{1}{2}$ acres
Plot No. 6	350	pounds	Superphosphate
	150	"	Potash
Plot No. 7	500	"	per acre, size $1\frac{1}{4}$ acres, plus 20 lbs. dusting
	350	pounds	Superphosphate
	150	"	Potash
	500	"	per acre, size $5\frac{1}{2}$ acres, plus 40 lbs. dusting
There was added to these plots the following dusting mixture:			
	50	pounds	Ammonium Sulphate
	30	"	Manganese
	15	"	Iron
	5	"	Copper
	100	"	used 40 pounds per acre.

The results were unsatisfactory, due to the fact that the spring and summer of 1934 were extremely dry, little if any rain falling in about 10 weeks. Because of the amount of fertilizer used (which would be proper in a normal season) some of the grasses were killed. Despite this the fall pasture was extraordinary. In 1935, these pastures were rejuvenated by spring rains and gave a good crop; during the summer a slight drouth did not reduce the quantity of grass more than we had anticipated, and in the fall we once more had wonderful pastures. While it was difficult to keep the grass growing in the extremely dry summer of 1936, there was an abundance of grass in the fall—so much so that it provided sufficient minerals and carotin for the animals to go into the winter highly protected. This resulted in development of an unusual crop of calves in the winter of 1936-37.

We expect to fertilize these pastures in this way every three years, with lime, superphosphate and potash; and when weather conditions permit, we shall use ammonium sulphate, nitrate of soda and ammo-phosphate every spring.

Heavy feeding, high in proteins, has been carried on by us for the past 15 years. This adds greatly to the fertilizer value

of manures. All manure produced has been used on the farm and in addition much commercial fertilizer has been purchased. Many experiments have been carried out with different minerals, resulting in a soil that is more productive, pastures of greater carrying capacity and higher feeding value, soil-improving hay and forage crops, and feed grains in abundance.

Natural grasses may be sufficient for the average cow producing about 200 pounds of fat a year; but when the milk yield is greatly increased, more mineral nutriment must be fed to furnish the product, preserve the health of the cow and develop the calf properly. We find a most satisfactory way to get these essential minerals into the cow is by fertilizing the pastures as well as the usual farm crops.

TIMOTHY HAY

For a number of years many farmers have expressed the opinion that timothy was not good for cows but should be fed to horses. The reason stated was that the barbs or spires in the head of this grass when ripened would interfere with normal digestion.

Timothy hay, when young, is good for the cow, if not more than 12 to 16 inches high and cut before it has headed out.

Timothy contains silicates which is a necessary accomple-ment to calcium and phosphorus so as to harden the bones.

The carotin or "green" of hay is the same as cod liver oil. Carotin, taken into the body, makes vitamin A.

Xanthophyl is a factor of reproduction, and is in the green hays.

Good green hays will put into the milk 1200 units of vitamin D potency per quart but, when dried in the sun, about 50 units only. Artificially dried hays produce approximately 950 units when properly done.

ALFALFA

"Early cut, well-cured, alfalfa has a high percentage of leaves and green color. The leaves contain more than two-

thirds of the protein of the entire plant. Green color in hay is associated with vitamin A, important in animal maintenance and reproduction. Vitamin A content is greatly reduced when hay is discolored from rain, sun-bleach, or improper storage. Alfalfa left in the sun at Arizona Station for less than three hours at noon lost 20 to 33%. A further exposure of four hours at noon the next day increased the loss to 84%. Severely bleached alfalfa, exposed for a week to sun and rain, lost 89%."

—(From the *Rural New Yorker*, Jan. 11, 1936).

Alfalfa has been found to give a larger production per acre than is obtained from either clover or timothy. We have grown it for many years and believe it to outyield any other variety of hay, usually producing two cuttings (and some seasons three cuttings) and enough after-math for winter protection. Our average yield has been approximately 2½ tons per acre.

The drying of grass quickly by hot air instead of over many days by the uncertain rays of the sun is probably the first of a series of changes from the old order of farming.

Hay used to be cut only once, or possibly twice, a year, whereas the young grass may be cut three to five times a year. Such procedure must be exhausting to the soil, for it removes nitrogen, potash and other constituents which have to be returned to it by the farmer.

This is being done satisfactorily in a number of locations but the expense is great. This method is highly remunerative for the product has a far higher feeding value, being richer in fat, sugars, and proteins than ordinary hay.

Naturally, standard practice is not yet available, as information is being sought on the exact time of cutting, the nature of the herbage, the proportion of each kind and many other variables.

The outstanding fact, however, is not the increased yield of grass per acre, but the quality produced and, further, that cows fed with it during the winter months give milk of summer

quality in regard to vitamin content, a result which has been attained in no other way.

It has always been stated by farmers that the second cutting of alfalfa was the best and we have for many years attempted to purchase only this and frequently paid a premium of as much as five dollars per ton. The claim was that the second cutting contained less fibre than any other cutting. As we always stripped the leaves from the stems and only fed the leaves it seemed to me that we were over emphasizing this fact and when we had an analysis made of the different cuttings we were certain of it. The first and third cuttings both contained about one-third more proteins and minerals than the second cutting, which only goes to show the fallacy of just guessing at facts.

CHAPTER VII.

AN ATTEMPT TO CURE GREEN ALFALFA BY MEANS OF DRY ICE

IN the fall of 1933 experiments were started to determine the feasibility of storing green or partly dry alfalfa in a silo, instead of storing dry alfalfa hay. Several 50-gallon steel drums were prepared as miniature silos. They were thoroughly cleaned inside and a circular section, about 18 inches in diameter, was cut from the head of each drum, and a 3/16" steel cover made to fit this opening. Each cover was drilled with four holes to receive 1/4" bolts which were welded to the top of the drum head, by means of which the covers could be bolted down over the hole in the drum head with a rubber gasket between the drum and cover to insure an air-tight closure. In use it was found that this was not sufficiently tight and that there was leakage, so the gaskets were eliminated and the cover made tight, after closing, by applying a plastic asphalt compound to the joint.

Carbon dioxide gas (CO_2) in the form of dry ice was used as a preservative to cure the green hay and prevent fermentation as well as to preserve the vitamins, chlorophyll, xanthophyll and carotins. In practical use the plan was to put the green or partly dry alfalfa through an ensilage cutter, cutting it directly into a silo, alternating layers of alfalfa and layers of dry ice, filling the silo and sealing it against leakage. The correct ratio of ice to hay was one of the important points we wished to determine.

The first experiment was started on October 3, 1933. Three drums were filled, one with damp hay, dried four hours; a second with green hay, cut and put in the drum at once, and the third with dry hay. Each drum contained layers of dry ice in the ratio of 280 cubic inches of ice to the 50-gallon drum, or approximately 42.4 cubic inches of ice to a cubic foot of hay.

These drums were stored away until May, 1934. When they were opened the hay in all three was found to be very damp, sour, and with considerable mold. Small samples of each were given to one or two of the animals and we noticed that they ate all of it except the parts which were moldy. Professor Erf was of the opinion that too much CO₂ was used, and that in the next experiment much less should be used.

In August, 1934, another storage was made, using only green and partly dry hay; as the dry hay in the first test was so poor that Professor Erf thought it was useless to try it again. One drum of green hay was prepared and one with hay which had been dried in the sun for four hours. CO₂ was again used in the form of dry ice, in the ratio of 2 cubic inches of ice to 1 cubic foot of hay, or 13.2 cubic inches of ice to the drum, broken up in small pieces and distributed through the hay as evenly as we could. These were sealed and put away until May, 1935.

These were in much better condition when opened than those of the previous year. The hay still retained much of its green color and still retained some of its moisture without being sour. There were spots of mold present, however, just as in the preceding test. The animals seemed to find it palatable and ate the samples which were given them.

In 1935 the test was similar to 1934 except that both drums contained green alfalfa. A very small amount of water was sprayed, in a fine mist, over each layer of hay in one drum and a spray of oil of mustard in the second drum, in an effort to prevent mold. These drums were sealed and stored on September 30, 1935.

Some thought has been given to curing hays by means of refrigeration and work along this line will be attempted. We believe, however, a temperature about 60° F. or lower will accomplish the results.

ALFALFA HAY CURING EQUIPMENT

(Winter of 1935-36)

Two (2) drums filled September 30, 1935:

No. 1 Drum: Green hay put in drum within 15 minutes of cutting. Alternate layers of tamped hay and dry ice. Each layer of hay sprayed lightly with cold water using a very fine spray from an atomizer. Opened July 11, 1936: Hay came out damp, moldy and very sour—smelled like vinegar. Dirty brown in color. Not fit for feed.

No. 2 Drum: Filled same as No. 1, except that oil of mustard undiluted was used for spray instead of water. Opened July 11, 1936: Hay came out with only one or two small mold spots near top, where it came in contact with sides of metal drum. It was not sour and had an odor much like green hay. There was a trace of mustard odor when the drum was opened but none in the hay when removed. There was no taste of mustard. Color was somewhat brown but not the dark muddy brown of No. 1 drum. Some of the leaves were green.

CO₂ in the form of dry ice was used in ratio of 2 cubic inches of ice to 1 cubic foot of hay, or 13.2 cubic inches to 50-gallon drum. Fifty gallons—6.6 cubic feet.

For three days just before opening the drum the weather had been very hot, over 100 degrees having been registered each day. This was the latest we have opened the drums since starting the experiments.

Samples from each drum taken and steam dried were sent to Professor Oscar Erf, at Columbus, Ohio, to be analyzed, also sample of fresh cut alfalfa dried by steam (not left in the sun) and a sample of good green first cutting alfalfa, sun dried as usual. Drum No. 1: This sample contained very little chlorophyll or carotin. Drum No. 2: This sample contained about half the chlorophyll and 69% of the carotin. Moisture appears to be a factor in deterioration.



AN ATTEMPT TO CURE ALFALFA HAY WITH DRY ICE AND A VACUUM

1936 EXPERIMENT IN PRESERVING GREEN HAY STARTED ON
SEPTEMBER 29, 1936

The 1936 experiment was similar to that of 1935 except that a partial vacuum in each container was provided. Four steel drums with air-tight removable heads were provided. Adjacent to the drums a single cylinder vacuum pump, having a capacity of 16 inches mercury vacuum, rated at 30 cubic feet in 7 minutes, was set up. A $\frac{1}{2}$ -inch pipe line was run from the pump over the drums with a branch line extending down to each drum. After the drums were filled with green hay the pump was started.

The original plan was to reduce the atmospheric pressure in the drum to 10 inches. In order to hold a pressure of 10 inches the pump switch was set to give a maximum of 16 inches

and a minimum of 10 inches. We found that the construction of the drums was not strong enough to stand 16 inches, so the vacuum pressure was reduced to 11 inches maximum and 7 inches minimum.

The drums were loaded as follows:

No. 1

Filled with hay and no dry ice. Top layer sprayed with oil of mustard.

No. 2

Filled with hay and with one pound of dry ice. Top layer sprayed with oil of mustard.

No. 3

Filled with hay and two pounds of dry ice. Top layer sprayed with oil of mustard.

No. 4

Filled with hay and four pounds of dry ice. Top layer sprayed with oil of mustard. This drum was not connected to vacuum as it partially collapsed and started to leak during the first pumping done when 16 inches of vacuum was reached. Another drum was not available so it was allowed to remain with only the dry ice and oil of mustard. Ice was placed in the bottom layer, close to the outside of the drum.

The above weights of dry ice used were based on the following ratio:

- 1 lb. ice in drum, equivalent to 17 lbs. ton of hay
- 2 lbs. ice in drum equivalent to 35 lbs. ton of hay
- 4 lbs. ice in drum equivalent to 70 lbs. ton of hay

The hay was cut in the morning, carried into the building out of the sun and was put into the drums at 2 o'clock. It had dried out so little as to hardly be noticeable.

(In 1936, used 70 lbs. dry ice to 2,000 lbs. hay, with a vacuum we hope to get this down to 10 lbs. dry ice to a ton of hay).

For the first six weeks the pump operated on an average of approximately 2 hours per day, then it began to operate less time so that by January 1st, it was operating only about 5 minutes each 24 hours.

By April 1st the pump was operating only about three minutes each 24 hours.

The drums were opened April 12, 1937.

CHAPTER VIII.

ULTRAVIOLET RAY

HAVING learned from the U. S. Department of Agriculture that this section has less sunshine than any other place in the United States exclusive of Seattle, Washington, and, further, that there is no ultraviolet ray effect in this section from October 1st to April 1st, and recalling the wonderful results we had with our hand-operated machines, we determined to ray all the animals. With this in mind, we took up with the National Carbon Company, Cleveland, the question of supplying lamps. Since ultraviolet rays are extremely short, they are easily filtered out, and little remains when the sunlight reaches the cow, due to dust, haze, smoke and sometimes ordinary window glass.

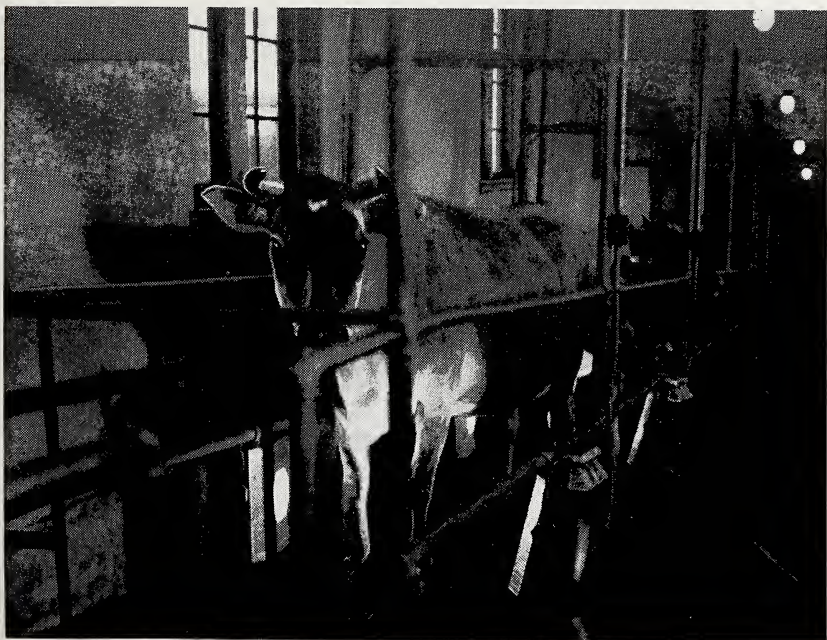
At first we did not get much cooperation. My honest opinion is that they thought we didn't know what we were talking about; but after getting these officials down here at the farm during August, 1932, and showing them just what we had done during the past three years with our crude hand-operated lamps, I think they were convinced that we really meant business. With this information they furnished us four M-1 lamps which we used during the winter of 1932-1933, and are continuing to use. We are raying three times each day for about five-minute periods and are obtaining partly satisfactory results.

The lamps are hung on the railings in the runway about a foot from the floor, two on each side. The noise created by the operation of the lamps attracts the cow and she is rayed through the eyes, nostrils and lips. She invariably moves up to the next light and not only is rayed as above stated but the two rear lights ray her belly and udder thoroughly.

We believe this has benefited our herd physically as well as somewhat increased the vitamin D in the milk, which in turn affects the calcium content. We are using National Carbon Company's therapeutic C carbon in the lamps.

Formerly we rayed, as explained previously, by hand lamps. This meant that the effect was on the body of the cow, the udder and the belly. This raying increased the thickness of the skin, and it became necessary to caliper the skin each week by means of a ratchet micrometer. If the skin thickened we reduced the intensity of the ray and vice versa. This was accomplished by use of quartz-glass shields of different thicknesses; the thicker the glass, of course, the less the penetration. These lamps are operated on a 110-volt 60-cycle circuit and use about 13 amperes each.

We also determined to put some ultraviolet lights in the test barn and have been trying to locate some of the old-style series arc lamps used 10 to 20 years ago; but, apparently, there is none in existence, and we have been forced to take a lamp constructed for use in blue-printing machines. These are hung



RAYING THE COWS ON THE RAMP WITH NATIONAL CARBON CO.'S M-1 TYPE LAMP

from the ceiling on a trolley and will ray two cows at a time; and, while it is not as effective as raying through the eyes, nostrils and lips, it is beneficial raying them on the backs and sides. As the distance from lamp to cow is greater we expect to ray for a longer period, about 30 minutes.

It was through the investigational work by Professor Erf of fur-bearing animals that had become decalcified that we began to use reflected light. We finally discovered that the reflected light at close range to the eye, nose, and ear gave us best results.

We presented this problem to Dr. Ernest Scott (now deceased), of the Ohio State University, and he became interested. Through the cooperation of the National Carbon Company we set up a series of experiments in which we decalcified a group of rats and then brought them back to normal by raying through the eye, nose, and ear. This then led us also to ray cows directly through the eye at short intervals. At first it was necessary to determine the possibility of developing conjunctivitis in the eye. This apparently did not develop with an average of one minute raying three times a day.

Experimental work is now being carried on to determine the amount of vitamin D developed in the milk of the cow by raying in various ways. As mentioned before, no direct raying system has yet been devised that will highly intensify vitamin D in the milk through the cow. This is because the ray of light thickens the skin, changes the color of the pigment and as a result light absorption is greatly reduced. We fully realize that vitamin D milk can not be produced in this way for the purpose of handling human pathological cases, for such cases require milk of vitamin D content in which the units are three or four times greater in number than can be produced in the cow.

There is still a moot question as to whether vitamin D in large quantities is injurious to the health of a normal child. A well-balanced milk in which vitamin D is standardized through



RAYING THE CALVES WITH PARAGON ARC LAMPS

the cow is much safer to our mind for normal children. This is done by raying the cow. We grant that rachitic children need milk high in vitamin D. By raying the cow we also have the advantage in not destroying other vitamins or other nutritional factors. We are, however, quite sure of the benefits that young animals derive from milk produced by cows that have been properly lighted and we feel that the same is true with children. At least quite a number have been fed on such milk with results that were quite satisfactory.

With this lighting method of increasing vitamin D in the milk there also seems a general improvement in the physical condition of the animal. Apparently the cow is able to produce a more nutritious milk, not only because of the increase of vita-

min D, but also because of the stimulative action of glands which contribute to milk formation. This work should be continued.

During January, 1936, we started raying the calves with a blue-printing machine lamp (Paragon Super Arc Lamps, manufactured by Paragon-Resolute Corporation, Rochester, N. Y.) hung approximately five feet above the floor, raying once each day, ten minutes in each location, six locations, total of one hour each day. We believe this is of considerable benefit to the calves.

CHAPTER IX.

FIRST TEST WITH RATS

THE OBJECT of this investigation was to determine the relation between raying and calcium. Dr. Ernest Scott, of the Medical Department of Ohio State University, who was directing these tests, died suddenly March 5, 1934, and, therefore, some delay occurred. The following results are listed not with the idea of producing definite conclusions but only to show the scope of the work done and the difficulties involved in any investigational work, especially where food and nutrition are concerned. These results were disappointing but they produced some information which will be helpful in our future experiments. These tests were made during the winter of 1933-1934 from milk supplied by Randleigh Farm. The results were reported to us by the Medical Department of the Ohio State University.

EXPERIMENT TO DETERMINE THE EFFECT OF IRRADIATION OF COWS
ON THE MILK PRODUCED BY THEM

Ernest Scott, M.D., O.S.U.

The purpose of this work was to determine the amount of vitamin D in milk from cows which had received ultraviolet light as compared with that from cows under the same conditions but which received no ultraviolet light. The different samples of milk were designated Green, Blue and Red. The Green came from cows which were irradiated in the special stall. The Blue came from the cows which were irradiated on the ramp and the light was directed into the animal's face. The Red came from cows which received no irradiation.

The experiments were carried out according to the method of Steenbock as nearly as possible. However, considerable deviations from this method occurred which will not allow a direct comparison between animals of different groups although a comparison can be made between any two animals in the same

group. For instance rat No. 6A (Chart 1) can not be compared with rat No. 50A (Chart 2), even though both received the same amount of the same kind of milk. But rat No. 50A (Chart 2) can be compared with any other rat on Chart 2 since all these rats were carried through under the same conditions, only the milk being varied. In addition it must be remembered that conclusions can not be drawn from the results on a few rats. The average of a large group must be considered. It is indeed unfortunate that out of this comparatively large group (113 animals) only a small number (21) may be used for vitamin determination. The reason for this unfortunate circumstance is as follows: In order to use the results of the line test in the determination of vitamin D the rats must gain at least four grams during the 10-day feeding period. However, all our rats except 21 either lost weight or failed to gain the required amount. In retrospection the reason for this wholesale loss is quite obvious. All the animals except the last nine were fed on a rachitic ration (2965) containing kiln-dried cornmeal. It was not until too late that this was realized and fresh corn was then obtained, ground and incorporated in the diet of the last group of rats. Each of these rats showed a substantial gain in weight during the test feeding period (at least 20 grams). This great difference between the reaction of the rats on two different rations is explained by the fact that meal ground from kiln-dried corn is deficient in vitamin A while that ground from fresh corn is not. Therefore, the milk had to overcome a vitamin A deficiency in addition to a vitamin D deficiency.

Experiment I

This experiment was carried out not for the purpose of vitamin D assay but to see the effect of the milk on very rachitic rats. Fifty-six rats at the ages of from 23 to 29 days and weighing from 35 to 60 grams were put on ration 2965 (see Note 1). These were kept on this ration plus water until

they began to die off. (It should be noted here that the rats began to show signs of vitamin A deficiency—ophthalmia and respiratory disease—before they showed rachitic signs.) Their death was probably due to the pneumonia which was found at autopsy. When the milk was added to the diet there were already 12 dead. The remainder (48) were divided at random into four groups and each group was placed in a separate cage. These groups received Green milk, Blue milk and Red milk, respectively. The fourth group received no milk. The milk, water and ration 2965 were given ad libitum and the amount of milk and ration 2965 was measured daily. Many of the rats died subsequently before the milk had time to take effect. As each rat died it was autopsied and its thoracic cage and both tibiae preserved. Under these feeding conditions it was impossible to know just how much milk any one animal consumed. Only the average amount for each group could be determined. After 20 days on the milk supplement all the remaining rats were killed. All the rats in the cage which received no milk were dead before this time.

All the rats which survived long enough to get milk for 20 days showed definite healing. This healing was due to the factors, the vitamin D and the calcium and phosphorus contained in the milk. Incidentally we may note that the Green milk produced a greater average gain in weight than the Blue milk. (Green, 35 grams; Blue, 9 grams.) This difference is much greater than the relative difference between the average amounts of milk consumed. (Green, 19.9 cc.; Blue, 14.8 cc.). It was also interesting to note that the ophthalmia (sore eyes) present in all the animals before milk was added to the diet, was cleared up in all but three of these which survived the 20-day feeding period.

No conclusions may be drawn as to the relative amount of vitamin D in the various types of milk because nearly all the rats were healed and no difference could be determined.

Experiment II

Eighteen rats aged 24 days and weighing 30 to 35 grams were put on ration 2965 for 24 days. At the end of this time they all had a waddling gait and marked enlargement of the wrist joints (signs of rickets). Two of the group were killed as controls and showed severe rickets. The remainder were divided into three groups, receiving Green, Blue and Red milk, respectively. All were kept in separate cages. The exact amounts of food and milk consumed daily were recorded. The animals were weighed at three-day intervals. At the end of the tenth feeding day the rats were weighed, killed and autopsied. Line tests were carried out on all of this group but as only four of them gained the required amount, they alone are included in Chart 1.

Although dependable data were meager in amount they indicated that 12 cc. of each type of milk was capable of producing plus 2 healing, which is that degree of healing desired in assay work. It was therefore decided that smaller daily amounts of milk should be used in the next experiment.

Experiment III

At the age of 32 to 35 days 29 rats were placed on ration 2965 for 22 days. At this time rickets were quite manifest so the test feeding period was begun. From the results of the previous experiment it seemed reasonable to decrease the amount of milk. Therefore the milk supplements were reduced to six cc., three cc. and one cc. daily, and there were three rats on each dosage so that a fairly dependable average could be determined. One rat was killed at the beginning to be sure they were rachitic. Two rats were kept on ration 2965 and no milk, these to act as controls. In addition three rats received ration 2965 plus cod liver oil equivalent to one Steenbock unit of vitamin D.

HISTORY OF RANDLEIGH FARM

CHART I (EXPERIMENT II)

Rat No.	Age in days	Days on 2965	Test Feeding Period (10 days)				Line Test (wrist)
			Total milk (cc)	Total 2965 (g)	Weights		
					1st day	last day	
11A	24	24	G84	34	43	52	Plus 2½
18A	24	24	B84	39	45	49	Plus 2
17A	24	24	B42	43	58	64	Plus 1
6A	24	24	R84	46	57	62	Plus 3
3A	24	25	No milk—Killed for control			53	S.R.
8A	24	25	“ “	“ “	“ “	50	S.R.

This only includes the controls and those animals which gained at least four grams during the test-feeding period.

CHART II (EXPERIMENT IV)

Rat No.	Age in days	Wgt. grams	Days on 2965	Test Feeding Period (9 days)				Gain in wgt.	Line Test (wrist)
				Total milk	Total 2965	Weights			
49A	36	45-60	22	R84	61	79	98 101	22	Plus 1
50A	"	"	"	R84	70	68	85 93	25	Plus 1
51A	"	"	"	R84	57	57	75 82	25	Plus 1
22A	"	"	"	B84	63	72	91 97	25	Plus 2
53A	"	"	"	B84	50	45	62 70	25	Plus 1
54A	"	"	"	B84	62	77	99 103	26	Plus 1
55A	"	"	"	G84	54	61	76 87	26	Plus 1
56A	"	"	"	G84	57	73	88 93	20	Plus 1
57A	"	"	"	G84	61	76	97 103	27	Plus 2
48A	"	"	"	Killed for control				63 grms	S.R.

The cornmeal in this group's ration was ground from fresh corn instead of kiln-dried corn. Note the consistent gains in weight.

These last three rats all showed at least plus 2 healing. The daily feeding of six cc. of any of the three types of milk was insufficient to produce healing in 10 days (see Note 2).

Experiment IV

When Experiment III was finished there were still 10 rats ready for the test feeding, that is, they were rachitic. These had been put on ration 2965 at the age of 36 days weighing 45 to 60 grams. They were definitely rachitic after 22 days on 2965.

Since six cc. of milk per day had been incapable of producing healing in the previous group it was deemed best to give all these rats 12 cc. per day so as to be sure to see some healing. One animal was killed as a control at the beginning of the test feeding period and it was rachitic.

It was at this point that we realized that the cornmeal was made from kiln-dried corn and so meal made from fresh corn was incorporated into a new batch of ration 2965 and fed to this group along with their milk. Instead of allowing these rats a full 10-day feeding period it was necessary to kill them at the end of the eighth feeding day. The results appear in Chart 2.

It is unbelievable to see how the change in the cornmeal altered the results. Every animal gained weight appreciably. The radius and the ulna (wrist joint) of every animal showed beginning healing, plus 1. In two of the animals, one fed on Blue milk, one on Green milk, there was plus 2 healing. If these animals could have been held over for the full 10 days we feel certain that the plus 1 reactions would have become plus 2 and that the plus 2 reactions would have become plus 3. If the assumption above is correct, it means that the Red milk has at least 11.2 Steenbock units of vitamin D to the quart, and that the Green and Blue milks contain more vitamin D (how much more we can not say). Milk from average cows fed on a good general ration contain from four to six units per quart. Remember that in order to have an assay valid the final dosage must be fed to at least ten rats and the results averaged.

In concluding we may say that there is a slight increase in the anti-rachitic potency of the milk from the rayed cows as compared with the milk from the unrayed cows. From these data we see no appreciable difference in the results of the two methods of raying upon the anti-rachitic value of the milk produced. In order to determine the exact amount of anti-rachitic substance more work must be done.

NOTE 1. Ration 2965 consists of the following:

Finely ground yellow cornmeal	76	parts
Wheat gluten	20	"
Calcium Carbonate	3	"
Sodium Chloride	1	"

NOTE 2. The test feeding period is conducted as follows:

The daily amount of milk is given only for the first seven days. For the last three days no milk is given. Ration 2965 is given daily (in measured amounts) for the full 10 days. The last three days without milk allows time for all the vitamin D to take effect.

Results in Tooth Formation

Since some dentists contend that clean milk from well-fed cows consumed in its natural state is necessary for the development of good teeth, it seemed possible to make some attempt to determine what effect the milk had in developing teeth with sound tooth tissue. Dr. Paul C. Kitchin, in charge of Dental Research of the College of Dentistry, Ohio State University, became interested in this problem. He had developed an improved method of grinding longitudinal sections of teeth so thin that cell structure can be easily seen through a microscope.

Teeth from the experimental animals were submitted to Dr. Kitchin and his conclusions are as follows:

THE OHIO STATE UNIVERSITY

GEORGE W. RIGHTMIRE, *President*

COLUMBUS

July 18, 1934.

COLLEGE OF DENTISTRY

H. M. SEMANS, D.D.S., *Dean*

DR. O. ERF,
Townsend Hall,
Ohio State University,
Columbus, Ohio.

DEAR DR. ERF:

The accompanying photographs were made from thinly ground sections of the constantly growing lower incisor teeth of your experimental rats. The one marked 20A was from an animal showing a severe case of rickets while 22A was from a rat which had made a recovery from a rachitic condition, as shown by the usual line test.

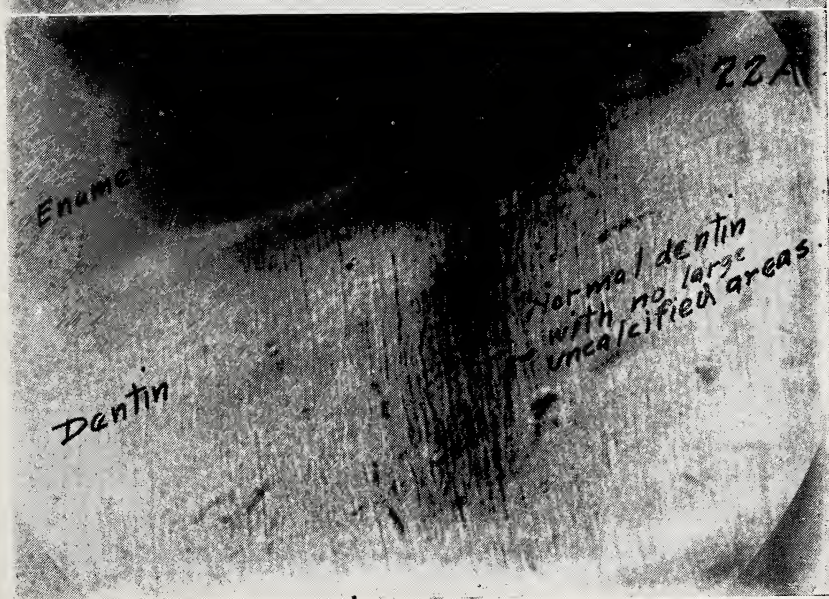
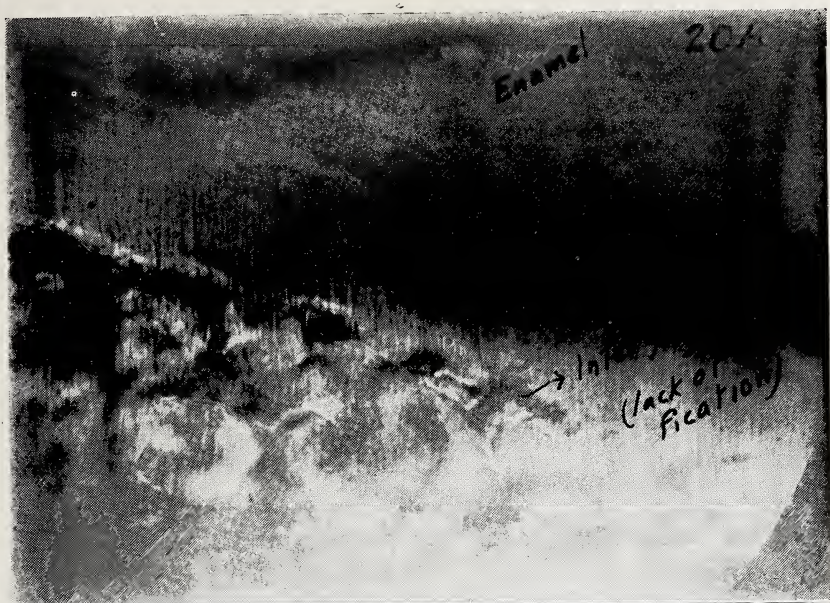
In both photographs the dentin, or internal body of the tooth, is shown in detail. In the normal calcification of dentin the finished product is quite uniformly impregnated by calcium salts with only the dentinal tubules remaining open and in communication with the central blood and nerve supply (dental pulp). Such a condition is shown in 22A. In poorly calcified dentin there remain large areas of the organic matrix, or ground substance, which do not become calcified. Such spaces are known as interglobular spaces. These are shown to a marked degree in 20A. Such a condition results in highly sensitive teeth in which dental decay progresses rapidly when once entrance has been gained into the dentin by the destructive organisms of the oral cavity.

Just what the relationship between the degree of rickets, as determined from the line test, and the interference with the normal calcification process of the dentin is, I am not prepared to state, but with similar conditions existing between the percentages of calcium salts in normal bone and in normal dentin it would seem reasonable to suppose that the effect might be noted in one about as quickly as in the other.

Certainly the desirability of building sound tooth tissues is unquestioned, because if no more were to be gained, densely calcified dentin would lower the rate of speed at which dental decay approached the pulp and make for greater possibilities in restorative measures before the pulp was seriously involved.

Very sincerely yours,

PAUL C. KITCHIN,
Associate Professor.



SECTION OF RATS' TEETH WITH AND WITHOUT RICKETS

CHAPTER X.

RAYING WITH NATIONAL CARBON COMPANY'S SOLARIUM LAMPS

THE RESULTS of raying cows in the test barn during the winter of 1933-1934 did not prove as satisfactory as expected. The National Carbon Company advised Professor Erf that they were of the opinion the lamps in use were not of the correct type, and it was agreed they would furnish two lamps to carry out the same experiment again in 1934-1935. It is now our belief that the failure of the 1933-1934 test was caused by the checking of the glass globes (made of "Corex D" glass), and the ash deposit which collected on the inside of the globes, acting as a filter for the ultraviolet rays, the effective rays being those between 2900 and 3050 Angstrom units.

Nevertheless new lamps were decided upon for the second test; and on October 11, 1934, the National Carbon Company shipped us two No. C-4B Solarium Type Lamps, which are twin arc motor control, normally drawing 60 amperes at 50 volts across the arc, operating from 220-volt 60-cycle line. These lamps are entirely automatic, having only one arc burning at a time, the motor control on the top of the lamp automatically bringing the second carbon into contact when the first has burned away a predetermined amount of carbon. They also have an automatic regulator to maintain constant voltage. Each lamp is equipped with a control cabinet in which are installed switch, fuses, contactors and transformers to change the line current of 220 volts 60 cycles to 50 volts 60 cycles, the correct voltage for the arc.

National Carbon Company "C" carbons were again chosen as the ones best suited to produce the desired frequency of ray. Because of our fear of fire hazard these lamps were furnished with sides made of Corning Glass Company "Corex D" glass to prevent particles of incandescent ash from dropping into the straw in the stalls. After a test run, however, it was found that

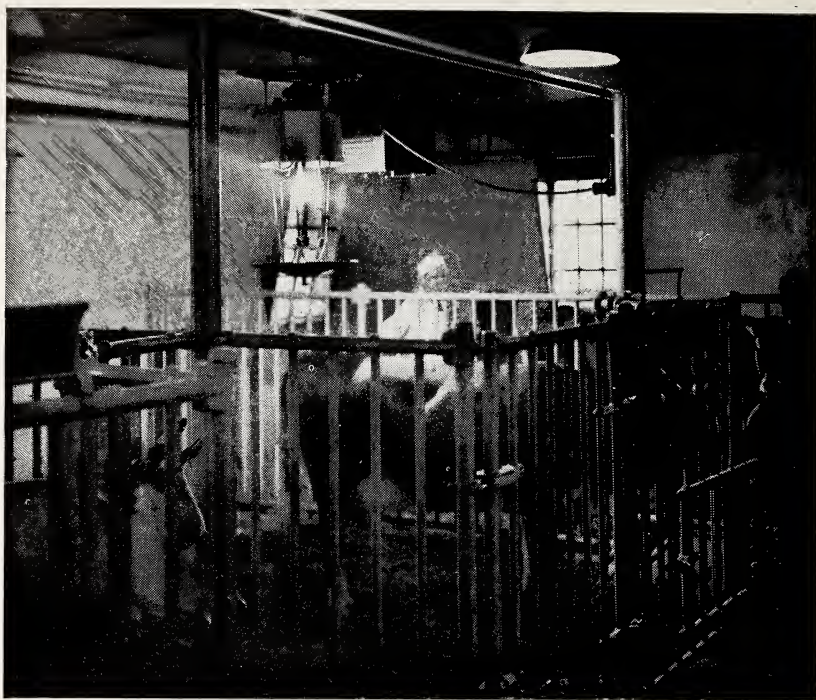
this hazard was not great and so the glass was removed and a sheet iron cone-shaped shallow pan was attached to the bottom of each lamp to catch such particles as did fall. The size of the pan was determined by cutting it too large and gradually reducing it until the shadow it cast did not interfere with the rays on the animal.

The lamps were suspended side by side by means of trolleys from tracks, one on each side of the test barn with 220-volt plug-in outlets provided at suitable points, so that the lamps could be rolled along the track from stall to stall. These outlets are placed so that each lamp, when plugged in, is directly over a partition fence between stalls, allowing the rays to strike two animals at a time—two exposures per day, 10 minutes each. In case an erythema develops during the test, 10 minutes more may be added to the time of exposure.

Last year a part of our primary line, 220 volts 25 cycles, was changed to 110 volts 60 cycles, in order to operate the M-1 lamps in the ramp near the milking stalls. This year we installed a switch at the distribution panel for this 110-volt line to divert the current when needed to the new lamps. This was then run to a transformer, temporarily installed, outside the building, transforming this 110-volt 60-cycle current to 220 volts 60 cycles, thence through four No. 10 wires in parallel to the test barn. The lamp installation was completed November 24, 1934, checked and tested by Mr. Melton, of National Carbon Company, on November 30th and raying of the cows started on December 3d.

Before we started the run we borrowed instruments from the New York State Electric & Gas Corporation and found the following conditions:

At the secondary side of the transformer with one lamp running 210 volts, two lamps running 162 volts; at the plug socket in barn, one lamp running 208 volts, two lamps running 160 volts. The frequency changer was installed to operate six

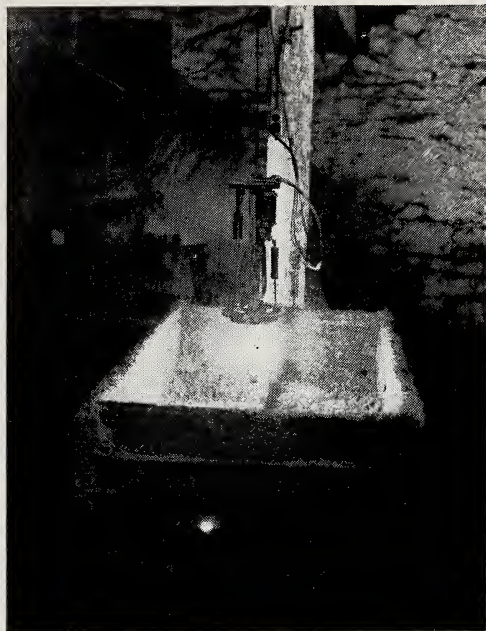


RAYING THE COWS IN THE TEST BARN WITH NATIONAL CARBON SOLARIUM LAMPS

M-1 type lamps and is not large enough to hold up the voltage for two of these large lamps. This can be corrected if a permanent installation is made at a later date. At the primary side of the control box of each lamp we found $23\frac{1}{2}$ amperes at 208 volts running load; 45 amperes at 208 volts starting load. At the secondary side of the box starting, *i. e.*, across the arc, we found—

60	amperes	at	50	volts	running	load
100	"	"	50	"	starting	"

These lights are so brilliant it caused some irritation in the eyes of men working in the barn. The use of amber-colored glasses seems to eliminate this trouble.



RAYING THE HYDROLIZED FEEDS IN VATS WITH A
BLUE-PRINTING MACHINE LAMP

These men were thoroughly tanned and their exposed skin frequently peeled off so that they resembled southern beach dwellers. It may be a coincidence, but one of the men working in the test barn had been troubled each winter for a number of years with sinus condition. This particular winter he was entirely free from this trouble. Moreover, one who looks after the Dairy Inn had been suffering from the same trouble; and when about the middle of the winter he was told by the first individual above mentioned the results obtained, although he was then affected, he commenced spending about a half-hour each day in the test barn, and was entirely cured for the balance of the winter. Whether this raying is effective on everyone we do not know, but we do believe these powerful lamps sterilize the air in the entire room and that is beneficial not only to the cattle per se but to every one working in the room.

One of the old lamps, a Paragon Super Arc Lamp, was installed in the old barn, near the feed bin, to ray the hydrolized feed for several animals. A temporary 110-volt 60-cycle line was run under the ramp into the barn, and the lamp attached to a pulley, by means of which it can be lowered into one of the feed mixing boxes. Sufficient feed for one feeding of two cows is placed in this box, the lamp lighted and lowered into the box. The feed is rayed 15 minutes, being agitated two or three times to insure complete exposure. When not in use the lamp is drawn up to the ceiling out of the way. We also tried raying the feed 30 minutes.

The complete test was as follows, each day one quart of milk each of the following kind being taken for samples:

A—From cows rayed in ramp at milking stalls.

B—From cows rayed in test barn with new lamps.

C—From cows not rayed at all.

D—From cows fed with irradiated yeast.

E—From one cow, high tester, fed rayed feed.

F—From one cow, low tester, fed rayed feed.

These milk samples were shipped daily to the College of Agriculture, Ohio State University, Columbus, Ohio, in cork-lined boxes from December 3, 1934, to May 15, 1935. After this date cream spread made from milk produced under these tests was shipped and appeared to be satisfactory.

Automatic Control of Lamps in Old Barn

During the winter of 1936 one of the new type lamps had been installed in the Old Barn so that it would travel at a uniform rate of speed about four feet behind the animals and at a height of six feet above the floor, raying all the cows the same length of time and avoiding over-exposure.

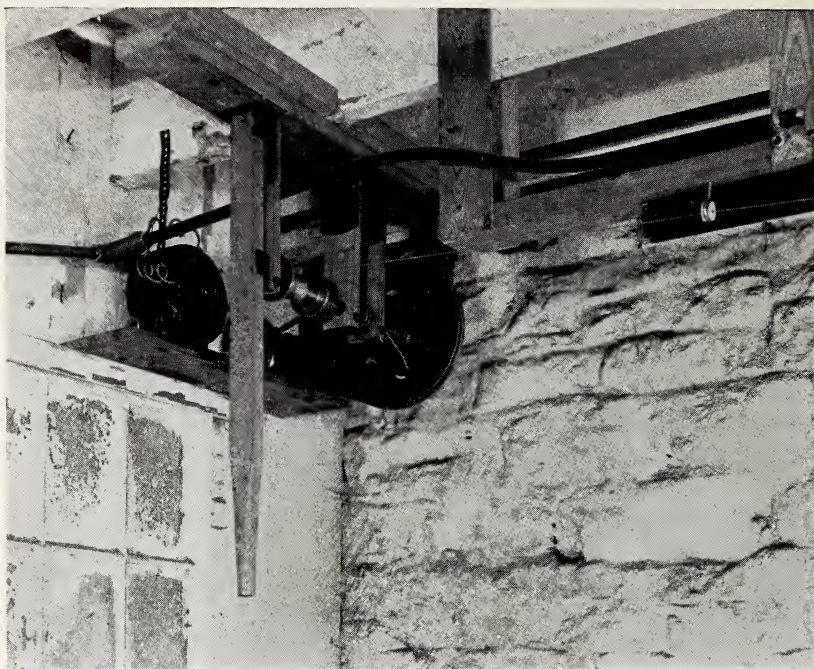
We tried operating the lamps two feet in front of the stanchions and five feet above the floor. The speed was the same (eight inches per minute), but this was not a success, since the

rays were so strong as to affect the eyes of the cows. We then returned to the first location behind the cows but lowered the lamps from six feet to 44 inches above the floor.

The mechanism to move the lamps uses an old washing machine motor running at 720 RPM. We purchased a small gear reduction unit with a ratio of 50 to 1 and mounted it with the motor on a wood platform suspended from the ceiling at the west end of the stalls. The motor was fitted with a two-inch pitch diameter V-groove pulley and belted to a six-inch pitch diameter pulley on the high speed side of the reduction unit. This belt reduction gives 240 RPM. on the high side of the reduction unit ($720 \times 2/6$), the 50 to one ratio reducing further to five RPM. on the low speed side ($240 \times 1/50$).



RAYING IN THE OLD BARN WITH SOLARIUM LAMPS



AUTOMATIC CONTROL OF THESE LAMPS

A two-inch pulley is mounted on the low side and belted to a 10-inch pulley mounted on a three-fourth-inch shaft, which is suspended on a homemade wood hanger about 12 inches in front of the motor platform. This reduction gives a shaft speed of one RPM. ($5 \times 2/10$).

On this shaft we mounted a flanged spool with six-inch circumference. Between the 10-inch pulley and this spool the shaft is cut and fitted with a simple clutch. The six-inch spool circumference at $1\frac{1}{2}$ RPM. gives a surface speed of six inches per minute. Enough flexible one-eighth-inch wire cable was attached to the spool to reach the full length of the stalls, approximately 90 feet.

The track from which the lamp is suspended was placed in line with the spool and the one-eighth-inch cable attached to the

lamp at the other end of the barn. When the lamp is lighted the motor is started and the shaft clutch engaged, winding the cable slowly around the spool, pulling the lamp toward it along the track. (The travel is exactly eight inches per minute, instead of six inches we expected, due to the fact that we used pulleys we had on hand, having slightly different diameters from the plan we made. We did not make new pulleys as Professor Erf thinks eight inches per minute is not too fast.)

The shaft clutch is operated by a shifter lever so that we can stop the lamp travel at any desired point. The motor is started and stopped by a toggle switch placed at the end of the track with an extension fastened to the toggle. A bracket on the lamp strikes this toggle extension when the lamp reaches the end of its run, putting the current to the motor. The whole installation requires no attention, once started, as it moves slowly past each cow, giving each a definite period of raying and stopping automatically at the end of the track.

The lamp is fed by 45 feet of rubber-covered cord plugged in at the center of the run, giving a total of 90 feet of travel. We intended to reeve this cord through a system of weighted pulleys to keep it off the floor and take up the slack, but it moves so slowly we shall not do this unless it is troublesome. The slack in the wire-pulling cable is taken up by stringing it through small open hook eyes attached to the track close to the rollers of the lamp hanger. A bent bracket attached to the lamp has a hole in its end through which the cable runs and by bending this bracket to the right position to the hook eyes, the cable is picked up out of the hooks, as the lamp approaches and is laid back into them as the lamp is drawn back.

Each animal is in the effective raying distance of the lamp for about 12 minutes, as it takes that length of time at the rate of eight inches per minute, to pass from a point four feet on one side to four feet on the other side of each animal.

CHAPTER XI.

THE SANITARY EFFECT RAYING HAS ON COWS

“CATTLE LICE are a serious handicap to the development of calves and heifers. When infested with lice young animals rub against posts and trees, wearing away their hair and inflaming their skins. Sometimes the calves become thin and weak from loss of weight.

“In the late winter and early spring, Fred M. Haig, associate professor of animal husbandry and dairying at North Carolina State College, states dairymen should inspect their calves to see whether they are infested with lice. The insects are found mostly around the necks and shoulders of the animals but they also infest other parts of the body.

“The first step in eradicating lice, Professor Haig says, is to clean and disinfect the stalls thoroughly. After removing the bedding and sweeping the stalls, disinfect them with a five percent solution of any good coal tar disinfectant. Allow the stalls to dry; then whitewash the interior. When the whitewash is dry, place plenty of straw bedding or other clean material in the stalls. Meanwhile, apply to the calves a solution of one ounce of sodium fluoride in a gallon of water. Brush it in thoroughly so that it will reach every part of the body and penetrate loose folds of skin. Tie the animals in a sunny place, protected from drafts, until they are dry. The calves are then ready to be placed back in the newly disinfected stalls, and a second treatment will hardly be necessary unless they become infested again from other animals.”—(From March 25, 1936, issue *Jersey Bulletin*.)

All this trouble is eliminated by raying, as shown by the following: For the first time we noticed the destructive effect these rays have on fungi, lice and other skin parasites, which commonly develop on the skin of cows where they are kept in

stables during the winter months. There was no evidence of any of these on the skin of cows that were rayed.

This is of great importance, especially where cows are stanchioned and do not have the freedom to lick themselves. The uncomfortableness naturally has an influence on both quantity and quality of milk. Skin scrapings from the backs of the rayed cows showed no living fungi by test. The cows went on pasture in the spring without the usual abrupt shedding of hairs. They apparently shed their hair gradually and constantly during the winter months. We have not determined all the factors surrounding the conditions that bring about sanitary effect, but more work along this line will be done in the future.

To show the original idea was correct, it may be noted that recently it has been found raying is effective in destruction of influenza germs in the human family.

CHAPTER XII.

SECOND TEST WITH RATS AND CHICKENS

SIMILAR TESTS on irradiation in its relation to vitamin D and calcium metabolism, as described in Chapter IX, were conducted again in the winter of 1934-1935, milk being used from cows of Randleigh Farm and fed to white rats and chickens in the laboratories at Ohio State University. Professor Erf suggested the following plan which was put into effect:

Following is a proposal for an agreement to be entered into between Randleigh Farm, the College of Agriculture, the Dental Research Department, and the Medical and Surgical Research Department of the Ohio State University:

The investigational work contemplated at Randleigh Farm involves the problem of raying cows in the most economical way for the purpose of increasing the vitamin D of the milk to a normal point, namely, to between 110-135 U. S. P. units per quart of milk and still retain unimpaired the other vitamins of the milk. The cows on Randleigh Farm, which are fed hydrolyzed feeds, produce milk with 90 U. S. P. units per quart of milk, without raying or feeding rayed feed.

As yet we have no better method for raising the calcium content of the blood in most high-producing cows than by raying with proper beams of between 2900 to 3100 Angstroms, for usually cows break down after completing a high record. As yet there has not been found a ray strong enough to introduce a normal amount of vitamin D into milk when the cow is producing extraordinarily large quantities of milk.

Whether this can be done most effectively by raying the cows continuously or whether it can be done by raying the feeds, or by raying some of the feeds in connection with raying the cows, needs to be determined.

Different methods of raying have been attempted. In 1932 raying was done by two methods at Randleigh Farm. The first

method was to ray the cow's udder without developing an erythema. This method was not a complete success because the tan which naturally developed seemed to prevent the production of vitamin D in milk. In this experiment the skin of the cow's udder was calibrated every week.

The second method was to ray through the eye of the cow for a short time. No conjunctivitis developed in the eye, and instead we found a stimulation if the raying was done only three times a day and for one minute at a time. In 1933 the eyes of the same cattle were rayed again for the second year. In 1933, also, cows were rayed with a blue-print raying machine. While some results were evident in many cases, the calcification seemed most favorable from raying through the eye in that year's experimental work.

On December 12, 1934, a third attempt was started to ray cows by various methods. A check group of cows will be kept out of the light. The check cows must produce about the same amount of milk as No. 2 and No. 3 group of cows, since the larger the amount of milk produced as a rule the lower will be the vitamin D content of the milk as determined by former experiences.

Milk from each of the following groups will be sent daily from Randleigh Farm to Dr. J. F. Lyman, Agricultural Chemistry Laboratory, Townsend Hall. Dr. Lyman will determine the vitamin D content of the milk biologically with rats and with chickens.

The experiments contemplated at Randleigh Farm are specifically:

(1) To determine the volume of light necessary for skin penetration of the cow to produce the normal amount of vitamin D in milk. Two lamps are provided by the National Carbon Company, and we will have an exact record of the volume and kind of light emitted. This light will be applied to 10 high-producing cows that give approximately the same

amount of milk as the cows kept in the dark, the control cows. At first those cows that are to be lighted will be exposed for 30 minutes daily. In case an erythema develops during the test, 10 minutes may be added to the time of exposure.

(2) To determine the volume of light necessary for eye penetration of the cow in order to produce the normal amount of vitamin D in milk. Cows will be exposed to light as they walk up the ramp. Each cow receives approximately three minutes raying per day, one minute at each milking. The entire animal will be rayed slightly, but the greatest impact of light will come through the eye. As has been stated, a one-year test indicated no conjunctivitis was developed from raying for short periods of time. In this case the amount of milk produced should be calculated in direct ratio with production of those cows that are lighted directly.

(3) To determine how much light can be incorporated in the feed, and how much vitamin D can be secured in the milk from cows fed this rayed feed. Further, this experiment is to determine how much vitamin D is found in both low and high-producing cows, as compared with the control herd. The time to which the feed is exposed should be from five to ten minutes, depending upon the intensity of the rays. This rayed feed is given to two lots of cows, one high-producing and the second low-producing.

(4) To check the vitamin D content of milk from feeding rayed yeast. The cows will be fed irradiated yeast. The cows used must give a large amount of milk, approximately the same as the test cows. The yeast should contain 1890 Steenbock units of vitamin D.

Vitamin D in the six samples of milk from the experimental cows will be tested by Griem's method, using 100 White Leghorn chicks. A check test for vitamin D will be made on white rats, using bone ash method of Hume, Pickersgill & Gaffikin.

RESULTS OF TESTS FOR VITAMIN D IN MILK FROM COWS IRRADIATED
WITH CARBON ARC LAMPS OR FED IRRADIATED FEEDS

Dr. J. F. Lyman, O.S.U.

The tests here described were made between December 1, 1934, and June 18, 1935. The cows used as subjects for the irradiation treatment belonged to the Jersey herd at Randleigh Farm. Six groups of cows were used:

Group I was the control. These animals were stabled in a barn basement and were not irradiated or treated in any way out of the ordinary routine used on Mr. Kenan's farm.

Group II consisted of cows fed similarly to those in Group I and irradiated for short periods three times daily by small carbon arc lamps located near the floor and to each side of the path by which the cows walked from the stable to the "Milking Parlor." Usually each cow stopped for a minute or two immediately before the lamps, of which there were four, waiting for the gate to open and admit her into the milking stall.

Group III consisted of cows kept in the test barn and irradiated twice daily 15 minutes each time from a powerful carbon arc lamp suspended above the animal.

Group IV consisted of high-producing cows fed a mixture of ground hay, sprouted oats, grain and mineral mixture, the whole of which had been moistened and fermented for 12 hours and then irradiated (while being stirred by hand) with a small carbon arc lamp.

Group V consisted of animals handled and fed like those of Group IV except that animals of lower milk production were selected for Group V.

Group VI consisted of cows fed in addition to the usual rations, irradiated yeast, furnished by the Fleischmann Yeast Company. Each cow received six ounces of the irradiated yeast per day.

Milk from each group of cows was shipped by mail each day except Saturday from the farm at Lockport, N. Y., to the labora-

tory at Columbus, Ohio, where the tests for vitamin D were made. The milk was delivered at the post office at Lockport at about 3:00 p. m. and arrived at the laboratory the following morning at 9:00. On a few occasions the milk failed to arrive until 2:00 p. m. and occasionally, early in the test work, an entire day and a half of another elapsed before the shipment came through. At all times except those when delivery was so long delayed as just mentioned, the milk was cold when opened and showed no indication of souring as far as could be judged by odor or taste. Soon after the milk arrived at the laboratory the feedings for the day were made. The milk delivered Saturday was kept in a cool place and used for the Sunday feeding.

Three kinds of tests were made:

I. Bone ash tests on rats caged individually and fed the Steenbock-Black rachitogenic diet consisting of yellow corn 76, wheat gluten 20, sodium chloride 1, and calcium carbonate 3. In the first test supplementary milk feedings were given at two levels, viz.: one cc. and five cc. daily. In two later tests the milk was fed at five cc. and 10 cc. levels to each test animal daily. The rats weighed between 30 to 70 grams at the beginning of the test. Feeding continued for 30 days when the rats were killed, the femur bones removed and extracted successively with 50 percent alcohol, 95 percent alcohol, and finally with ethyl ether. Irradiated ergosterol (viosterol) was used at the levels of 0.1 and 0.2 international vitamin units daily for control purposes.

II. Bone ash tests on chicks. The method following was that described by Griem in the Journal of the Society of Official Agricultural Chemists, Volume 17, page 69, 1934. The milk to be tested was mixed with the Griem basal ration at three levels: 0.5 cc. milk per one gram ration, 1.0 cc. milk per one gram ration and 2 cc. milk per one gram ration. The milk and basal ration mixture was kept before the chicks continuously.

The chicks were White Leghorns, two days old at the start of the test. After 30 days feeding the chicks were killed, the femur bones dissected out and extracted with alcohol and ether.

III. Line test on rats using the procedure recommended by the Vitamin Assay Committee of the American Drug Manufacturers Committee, Journal of the American Pharmaceutical Association, Volume 21, pages 598 to 600.

SUMMARY AND CONCLUSIONS

<i>Bone Ash tests on rats:</i> <i>Treatment</i>	<i>Gain in Body Weight</i>		<i>Percent of Bone Ash</i>	
	<i>Test I</i>	<i>Test II</i>	<i>Test I</i>	<i>Test II</i>
Control 0.1 D Unit	45	38	43.5	51.24
Control 0.2 D Unit	51	43	47.5	51.56
5 cc. milk from Group I . . .	49	62	34.5	39.78
5 cc. milk from Group II . . .	48	63	32.8	37.55
5 cc. milk from Group III . . .	52	77	38.9	49.96
5 cc. milk from Group IV . . .	..	59	....	37.13
5 cc. milk from Group V . . .	41	50	36.7	45.52
5 cc. milk from Group VI . . .	..	41	....	51.78

<i>Chick Tests:</i> <i>Treatment</i>	<i>Weight of Chick</i>		<i>Weight of Bone</i>		<i>Weight of Bone Ash</i>		<i>Percent of Bone Ash</i>	
	<i>Test I</i>	<i>Test II</i>	<i>Test I</i>	<i>Test II</i>	<i>Test I</i>	<i>Test II</i>	<i>Test I</i>	<i>Test II</i>
Control	169	100	.4085	.2004	.1330	.0643	33.23	32.4
½ cc. milk Gr. I	148	165	.3706	.3475	.1380	.1259	37.70	36.4
1 cc. milk Gr. I	167	163	.3623	.3806	.1298	.1365	38.42	36.9
2 cc. milk Gr. I	192	168	.4102	.4066	.1498	.1357	36.63	33.6
½ cc. milk Gr. II	184	139	.4549	.3242	.1516	.1118	33.40	34.5
1 cc. milk Gr. II	164	155	.3861	.3625	.1403	.1384	35.28	37.0
2 cc. milk Gr. II	156	160	.2639	.3959	.1365	.1417	38.51	36.3
½ cc. milk Gr. III	168	144	.4127	.3691	.1539	.1298	38.32	31.54
1 cc. milk Gr. III	212	147	.4490	.3598	.1517	.1247	38.79	34.7
2 cc. milk Gr. III	138.7	163	.2533	.3461	.0911	.1232	36.13	36.2
½ cc. milk Gr. IV	181	140	.5156	.3256	.1648	.1194	32.04	36.7
1 cc. milk Gr. IV	185	166	.3852	.3726	.1475	.1354	38.59	36.5
2 cc. milk Gr. IV	185	193	.3755	.4192	.1447	.1550	38.19	34.6
½ cc. milk Gr. V	153	170	.3562	.3909	.1250	.1290	34.77	33.0
1 cc. milk Gr. V	174	165	.3784	.3973	.1411	.1393	38.06	35.1
2 cc. milk Gr. V	187	168	.4087	.3791	.1482	.1368	35.93	35.8
½ cc. milk Gr. VI	...	163	.....	.3760	.....	.1356	.....	36.2
1 cc. milk Gr. VI	...	160	.....	.3645	.....	.1314	.....	36.3
2 cc. milk Gr. VI	...	156	.....	.3658	.....	.1419	.....	39.2

Conclusions

There was some difficulty in making the line test in producing rickets in the test animals. The induction period had to be extended to 28 days instead of the usual 21 days. As a result of long feeding on the poor ration a large number of the test animals died, failed to eat sufficient food or supplement, or

failed to gain in weight. The number of animals satisfactory for the test was therefore too limited. In the following summary of results the maximum degree of healing is indicated by "4", no healing by "0" and healing of intermediate extent by figures between "0" and "4".

Amount of 70% Cream Fed	Number of Group						Negative Control
	I	II	III	IV	V	VI	
4 grams	1.5*	0.6	2.0	2.5	0.6	2.3	0.5
8 grams	0.5	1.5	1.5†	2.5‡	1.0	3.5	

*Only two animals. The others refused to eat, died or did not make the required gain in weight.

†Only two animals.

‡Only one animal.

The line test shows some vitamin D activity in some of the milks, particularly that produced from cows fed irradiated yeast. Group III from the irradiated cows receiving the irradiation from the large carbon lamps and Group IV from the high-producing cows fed irradiated feed seem to be superior to the other specimens of milk.

The general conclusion from the rat tests, bone ash and line, is that irradiation of the cows or of the feed with sufficient ultra-violet radiation has an effect upon the milk produced, so that growth and bone quality of rats fed thereon are favorably affected.

In both tests milk from the cows irradiated 30 minutes per day from powerful carbon lamps (Group III, rat bone ash tests) when fed to rats at the level of five cc. per rat per day as supplement to the Steenbock-Black rachitogenic diet produced a marked increase in body weight and percentage of bone ash was greater in the rats fed the milk from the cows irradiated from the large carbon arc lamps (Group III) than in any other groups of rats except that higher bone ash was produced in rats fed irradiated ergosterol (viosterol) and in those fed the milk from cows receiving irradiated yeast. How much of the beneficial effect on rats from the milk of the cows in Group III is due to an increase in vitamin D as a result of the irradiation of the cows can not definitely be decided because other factors may be involved; for example, an altered salt or mineral content of the

milk, which conceivably might occur as a result of the irradiation of the cows, might produce growth responses in the rats under the conditions of our tests.

The basal ration used in the Griem chick test for vitamin D is believed to be well-balanced except that it lacks vitamin D. Day-old chicks fed this ration alone for 30 days and kept indoors show a bone ash content in the femur bones of about 30 percent. Any additions of vitamin D raise the bone ash content. The test is used for quantitative purposes by finding by trial how much of the material being tested must be fed daily to increase the bone ash content to 40 percent. The test seems to be satisfactory for the assay of cod liver oil. The results from feeding the various milk samples have been inconsistent. The interpretation of the results is baffling. In all cases adding milk to the basal ration raised the bone ash content decidedly and increased the gains in live weight; however, these effects are not at all proportional to the amounts of milk fed. There seems no basis in the chick tests for coming to a conclusion as to the relative merits of the differently produced milks.

These results are quite gratifying when the daily large amounts of milk produced by these cows is taken into consideration. The associated factors in the feed ration must apparently have some influence on calcification.

A conference at the farm took place in November, 1935, with Professor Erf, Dr. Lyman, Dr. Kitchin, of Ohio State University; Dr. Dorcas and his assistant (Mr. Anderson) of the National Carbon Company, Cleveland, present, the purpose being to arrange in detail the research experiments for the winter. At this conference the National Carbon Company agreed to furnish the third C-4B Solarium Type Lamp which they did promptly and we had all three in use during the past two winters. It was a most satisfactory meeting and much good accrued from it. This work continues our investigation of calcium and phosphorus, together with vitamin D, which has been carried on for the last two years.

CHAPTER XIII.

THIRD TEST ON EFFECT OF ULTRAVIOLET IRRADIATION
UPON VITAMIN D CONTENT OF MILK

By Dr. J. F. Lyman, The Ohio State University

THE experiments of 1935-1936 were a continuation of those of former years with the object of finding the effect of ultraviolet irradiation of dairy cows upon the vitamin D content of the milk produced by them. Vitamin D is usually present in cows' milk in small amounts only, varying according to the feed of the cows and the season of the year from about 15 international units per quart up to about 45. The higher values are usually obtained when the cows are on summer pasture and the lower values when they are on dry feed in winter. Even the higher values are insufficient to cure or prevent rickets in infants fed the milk without vitamin supplements.

Experimental Methods

Instead of irradiating the cows in box stalls as in former years and using as controls the non-irradiated cows in stanchions, the arrangement was reversed. In this year's tests then, the cows kept in the stanchions were irradiated by a carbon arc light, described elsewhere, and suspended on a carrier so arranged that the lamp travelled behind the line of cows at a rate of eight feet per minute, with two single trips per day. In this arrangement there was no opportunity for the ultraviolet irradiations to act upon the feed in the mangers in front of the cows. For a few days the light was changed to a carrier in front of the cows, but this caused so much irritation to the eyes of the cows that it was moved back to the former position behind the cows. Light treatment began in November and continued until May.

The milk was shipped daily in the evening, except Saturday, by mail from Lockport to Columbus. It arrived, with few exceptions at the laboratory on the nine o'clock delivery the follow-

ing morning. The milk was usually cold on arrival and only rarely showed any signs of souring.

The bone ash technique was used as the vitamin D test and there were two tests: 1, on the milk and 2, on the 70-percent cream separated from the milk.

White rats about 25 days of age and weighing about 50 grams were put upon the Steenbock rachitogenic diet. The negative controls were fed upon this ration alone throughout the test period. Group I were fed the Steenbock diet, ad libitum, plus five cc. per rat of milk produced from cows fed six ounces of irradiated yeast per cow per day. Group II received as supplement to the Steenbock ration five cc. of milk produced from cows without any special treatment. Group III received as daily supplement five cc. milk produced by cows fed two and one-half ounces of yeast per day and irradiated themselves with carbon arc lamps. Group IV received daily per rat, five cc. of milk from irradiated cows which were fed the usual dairy ration. The rat feeding tests on the milk began January 2, 1936, and continued until May 9, when the cows were turned out on pasture.

Two samples of 70-percent cream were received at the laboratory in November. These samples represented the product in one case of a cow with a high butterfat production and in the other, of a cow of lower production. Neither cow had been artificially irradiated at the time these samples were taken. An attempt was made to measure the vitamin D content of these samples by means of the usual line test technique. This effort failed because the animals available for the test showed such a resistance to rickets that it was impossible to apply the curative treatment. The two samples of cream were stored in a refrigerator maintained at about 20° F. until the following September when they were assayed by the bone ash technique.

Four samples of 70-percent cream were taken in early May at the end of the irradiation test. These four cream samples

were stored in a refrigerator at about 20° F. until September when they were assayed by the bone ash method.

The vitamin D material used as standard of reference in the cream feeding tests was obtained from the United States Department of Agriculture and was supplied to them by the League of Nations through whom it had been standardized.

THE SUMMARY OF RESULTS WITH MILK FEEDING

Group	Start of Test	Days on Steenbock Ration	Days on Milk	Average gain in Weight	Average Percent
I	Jan. 2	37	22	45	51.09
II	Jan. 2	37	22	37.6	40.51
III	Jan. 2	37	22	43.3	55.65
IV	Jan. 2	37	22	39.4	48.65
I	Jan. 2	60	47	89.5	59.06
II	Jan. 2	60	47	75.0	46.93
III	Jan. 2	60	47	77.0	60.36
IV	Jan. 2	60	47	67.5	53.11
I	Mar. 10	31	31	60	59.8
II	Mar. 10	31	31	61.8	57.44
III	Mar. 10	31	31	60.4	60.38
IV	Mar. 10	31	31	59.6	59.35
Negative Control	Mar. 10	31	None	22.7	41.28
I	Mar. 10	59	59	83	62.51
II	Mar. 10	59	59	113	62.81
III	Mar. 10	59	59	105	61.16
IV	Mar. 10	59	59	95	62.34
I	Mar. 10	59	34	86.6	59.25
II	Mar. 10	59	34	73.3	57.58
III	Mar. 10	59	34	83.6	60.84
IV	Mar. 10	59	34	83.6	59.77

THE SUMMARY OF RESULTS WITH CREAM FEEDING

Sample	Days on Steenbock Ration	Days on Cream 0.3 g. fat per day	Gain in Weight	Bone Ash Percent	I. U. Vit. D per g. fat
Nov. High Producer..	60	30	—1.6	45.14	5.66
Nov. Low Producer...	60	30	—2	39.08	1.38
May Group I.....	60	30	+3.9	44.71	5.12
May Group II.....	60	30	+1.7	44.37	4.73
May Group III.....	60	30	+9.2	45.73	6.50
May Group IV.....	60	30	+4.9	47.43	9.68
Negative Control	60	None	—3.4	30.23	
0.1 I. U. Vit. D per day	60	None	—8.3	33.01	
0.2 I. U. Vit. D per day	60	None	—4.6	35.95	

HISTORY OF RANDLEIGH FARM

IN TERMS OF INTERNATIONAL UNITS OF VITAMIN D PER QUART OF SIX-PERCENT MILK, THE RESULTS ARE:

<i>Milk Sample</i>	<i>International Units of Vitamin per quart</i>
High-Producing Cow (November)	306
Low-Producing Cow (November)	75
Cows fed Irradiated Yeast (Spring)	276
Cows without Special Treatment (Spring)	255
Cows Irradiated and fed Irradiated Yeast (Spring)	351
Cows Irradiated (Spring)	523

Discussion of Results

It will be seen from the tables that the length of the milk feeding periods varied from 22 days to 59 days. The shorter period was found more satisfactory in bringing out differences in the various milks. When the test period is too long, bone ash reaches about its maximum even on the poorest milk when five cc. per day is fed.

In all the tables Group I is that group which received milk from cows fed irradiated yeast. Group II received milk from cows that had no special treatment of any kind; they were the control group. Group III received milk from cows that were fed irradiated yeast and that were themselves irradiated by the carbon arc lamps. Group IV received milk from cows that were irradiated but whose feeding was the same as that of the control group.

Our plan was to use the "line test" method for the assay of vitamin D in the cream samples. Accordingly we secured a supply of young rats from a commercial breeder and started them upon the Steenbock rachitogenic diet in August, 1936. At the end of 18, 21, and 28 days on this diet a rat was killed and the wrist bones examined by the silver nitrate staining method. Rickets did not develop sufficiently for us to use these animals for the line test; therefore we decided to use these rats for the bone ash technique of Kon and Henry (*Biochemical Journal*, 129, 2051, 1935).

Accordingly we divided the rats into groups of about seven animals each. One group was continued upon the Steenbock

ration, without supplement, as the negative control. Another group was given in addition to the Steenbock diet 0.1 international unit of vitamin D per rat per day, a third group was given 0.2 international units of vitamin D per rat per day. Six groups were used to assay the six cream samples. In all cases sufficient cream was fed to furnish 0.3 gram of butterfat per rat per day. The effects upon body weight and bone ash are shown in the table.

One striking feature of the results is that all the bones (femurs) are higher in ash than those from the rats used in last year's test. This may be due to some unknown difference in the chemical composition of the Steenbock rations used in the two years or it may be due to unusually high vitamin D reserves in our test animals at the beginning of the test. The latter possibility is a likely one since we purchased all the animals used and their history was unknown to us.

Among the milk tests those begun January 2 with a milk feeding period of 22 days are regarded as most satisfactory. In this test the bone ash varied from 40.51 percent for the rats fed the milk from the control group of cows to 55.65 percent for the rats fed milk from the cows fed irradiated yeast and in addition treated with ultraviolet irradiation. In this test there was a bone ash of 48.65 percent for the rats fed the milk from the irradiated cows and a bone ash of 51.09 percent for the rats fed the milk from the cows fed irradiated yeast.

The tests started on March 10 were not entirely satisfactory because the animals used showed an unusually high bone ash when fed the Steenbock ration without supplement. The negative control on the animals used in this test was 41.28 percent against the usual value of about 30 percent. All the bone ash values obtained upon the rats purchased on March 10 are higher than we expected and there are less differences between the various groups; however, the lowest bone ash again is for the rats fed milk from the control cows; the highest for the rats fed milk

from the cows receiving the double treatment of yeast feeding and irradiation with intermediate values for the rats fed the milk from the irradiated cows and those fed milk from cows fed irradiated yeast.

The results of the cream feeding experiments seem to be rather inconsistent and indicate a much higher level of vitamin D in the cream than we expected to find. Too much importance should not be attached to the quantitative measurements for vitamin D in the cream samples.

Reference to the appended graph, in which the percentage of bone ash is plotted against the logarithm of the dose of vitamin D, according to the recommendation of Henry and Kon, shows that a bone ash of 43 percent is obtained with a daily dose of one international unit of vitamin D per day. Since the rats fed .3 gram of butterfat daily from the irradiated cows had an average bone ash content of 47.4 a daily dose of much more than one unit of vitamin D per day is indicated; but there may be considerable error in applying the equation for the curve to a bone ash in this region. (Graph shown in Appendix, page 298.)

However, we have a way of checking the accuracy of the results to a certain extent. The cows in Group I that were fed six ounces of irradiated yeast daily per cow should have produced milk with a vitamin D value of 450 international units per quart. Our determination indicated only 276 units.

The greatest inconsistency among the results is the value of 255 units per quart found for the milk from the cows that received no special treatment.

In the cream test nearly all the effect of the cream on bone ash would be due to vitamin D. With the milk feeding tests, on the contrary, a part of the effect may be due to vitamin D, but another and probably considerable part of the effect may be due to the phosphate salts of the milk.

At any rate the cream feeding had a remarkable effect upon the bone ash. Again the lowest value was obtained for the

control group. With the cream, however, the highest value was obtained from the group of irradiated cows with intermediate values for the other two groups. The value of 255 international units of vitamin D per quart of milk from cows with no special feeding or lighting treatment seems impossibly high. We intend to check this result carefully in this year's test. From our experience during the last two years we have learned much about the assay of vitamin D in milk and cream.

It should be mentioned here that all the cows in Mr. Kenan's herd are fed a rather unusual ration which may have some influence upon the vitamin D content of the milk produced. The ration used contains freshly sprouted seeds which are mixed with the ground hay and ground grains and the whole mass moistened with warm water and "digested" overnight. In addition to this prepared feed the cows are given about as much loose hay as they will clean up.

Olson and Wallis in Bulletin 296, South Dakota Agricultural Experiment Station, 1935, have reviewed the literature on vitamin D in milk. In their own experiments they determined the bone ash in rats fed butterfat from summer milk, fat from winter milk and basal ration. They used no artificial irradiations. However, our results harmonize with theirs to the extent that they also found much greater effect on bone ash from the irradiated cows. They made no attempt to determine how much of this effect was due to light and how much was due to the summer feed. Their results were as follows:

<i>Ration</i>	<i>Percent Bone Ash, First Trial</i>	<i>Second Trial</i>
Steenbock rachitogenic	27.06	28.83
Steenbock + 5% summer butterfat.....	44.88	43.44
Steenbock + 10% summer butterfat.....	50.14	46.56
Steenbock + 5% winter butterfat.....	30.17	37.06
Steenbock + 10% winter butterfat.....	34.56	40.62

The winter butterfat used in the second trial was different from that used in the first trial; but the same summer butterfat was used in both.

After reviewing the experiments on the irradiation of dairy cows they conclude with the statement, "Consideration of the information available forces the conclusion that an intelligent statement as to the exact effect of artificially irradiating a cow with ultraviolet light on the vitamin D potency of the milk produced can not be made at the present time. Results to date are confusing. While some investigators have been able to demonstrate an appreciable enhancement of the anti-rachitic properties of the milk by irradiating the animals, others have been unable to do so."

Summary and Conclusions

Four groups of Jersey cows were used to find to what extent the vitamin D content of the milk could be increased by irradiating the cows with ultraviolet rays produced by the industrial type carbon arc lamp, developed by the National Carbon Company, and giving radiations of 2500-3200 Angstrom units of such intensity that it will produce an erythema to the average human being in less than five minutes.

As positive control the cows in Group I were fed irradiated yeast. As negative control the cows in Group II received no special treatment. The cows in Group IV represented the experimental group. They were irradiated from behind at regular intervals for measured time. The cows in Group III were irradiated and fed irradiated yeast also.

The milk and 70-percent cream from the four groups of cows were fed to white rats maintained upon the Steenbock rachitogenic ration and the bone ash determined after an interval of feeding.

The general conclusions from this year's tests appear to be:

1. Ultraviolet irradiation of the cows as carried out in these tests was about as effective in increasing the vitamin D content of the milk as was the feeding of irradiated yeast.
2. The combination of irradiation of the cows with ultraviolet light and feeding irradiated yeast produces milk with higher

bone ash-forming qualities than either treatment separately. In the cream tests the highest values for vitamin D were found in the cream from the irradiated cows; however, the differences between the cream from the irradiated cows and the cream from the combination treatment may not be greater than experimental error. We propose to continue the tests upon the 70-percent cream samples and discontinue those on milk.

RELATION BETWEEN BONE ASH AND CALCIFICATION OF DENTIN IN TEETH

Paul C. Kitchin, D.D.S., Ohio State University

The incisor teeth of the white rat grow constantly during the life of the animal, being completely replaced about every 45 days. Therefore, they are good indicators of the progress of the process of mineralization. The dentinal part of the incisor in particular is quick to show the result of any lack, below the minimal requirements, of minerals and vitamin (in the diet), which are essential for good bone and tooth development.

In order to examine the character of the dentin of the rat incisor tooth, a very thin section (approximately 10/25,000 of an inch) is ground out in such a way as to include the whole length of this tooth. Figure 1 is a photograph, much enlarged, of such a section of a half of a lower jaw of a white rat. In addition to the lower incisor tooth this shows sections through the molars and the bone of the jaw. The area included in the square indicates the area of examination in all the different sections studied in connection with this project.

Bone ash percentage determination made upon the skeleton of experimental rats is a recognized method of ascertaining the sufficiency of the diet in minerals and vitamin necessary for calcification. In order to show the marked changes in the tooth structure which accompany differences in bone ash percentage, it was necessary to select a fairly wide range of these percentages.

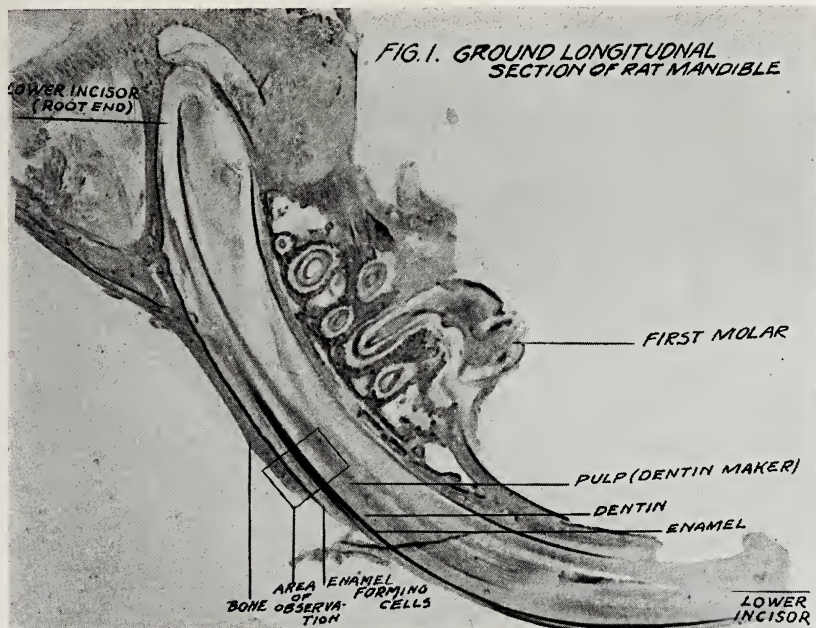


FIGURE 1. Thin ground longitudinal section of rat mandibula, enlarged. Shows continuously growing incisor. The small area marked is the basis of subsequent illustrations.

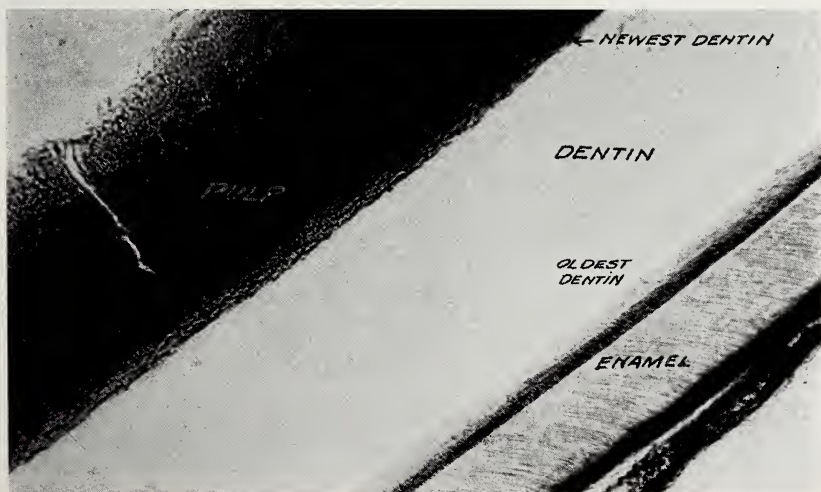


FIGURE 2. An area corresponding to the marked square in Figure 1 in a tooth in which the bone ash was 51.32 percent. This shows a uniformly well calcified dentin.

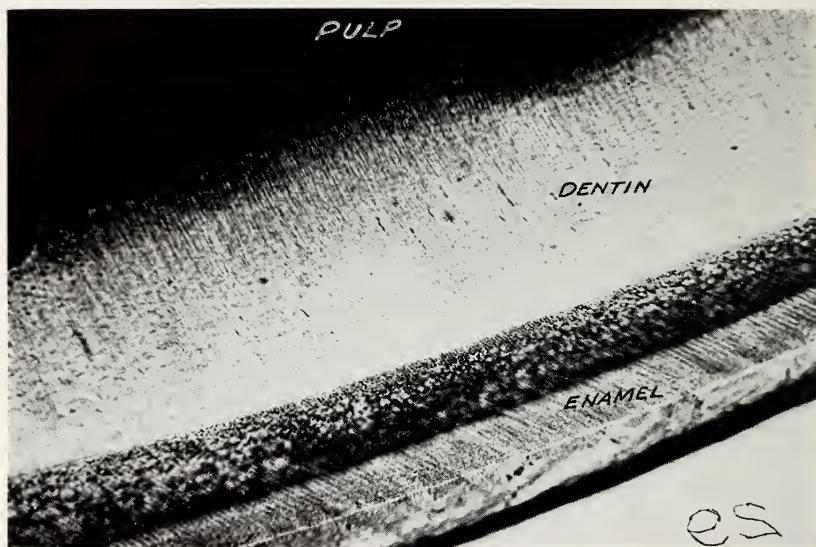


FIGURE 3. View of an area of a tooth which gave a bone ash determination of 37.90 percent. Note mottled appearance of dentin due to uneven calcification.

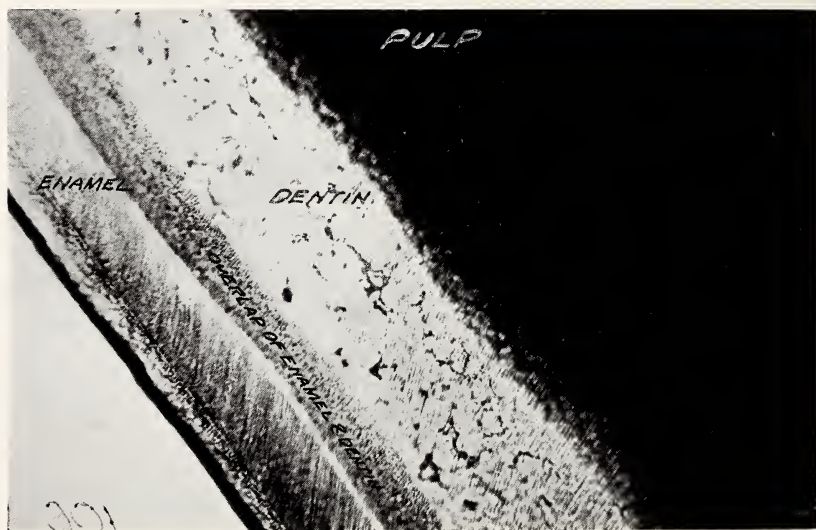


FIGURE 4. Typical (interglobular spaces) defects in the dentin accompanying lower bone ash. Percentage of bone ash is 28.26 percent.

Since the 1936 rat series ground out in our investigation showed no low bone ash percentages, there has been selected for this purpose three quite widely varying rats from the 1935 group.

Figure 2 is a photograph, enlarged, of a ground section in an area corresponding in location to the square in Figure 1 of an animal whose bone ash was determined by Dr. J. F. Lyman as 51.32 percent. The dentin calcification is quite uniformly dense and of a normal well-formed type.

Figure 3 is a section of a rat tooth where the bone ash of the skeletal bones was determined as 37.90 percent. It is quite evident that the dentin here differs in appearance from that shown in Figure 2. There is not a uniform density but rather a mottled appearance, denser in some places than in others. It is apparent here that a different condition in the tooth dentin is associated with the lower bone ash percentage.

Figure 4 shows the appearance of the dentin in a rat whose bone ash was quite low, 28.26 percent. It illustrates the typical defects occurring in the dentin structure with a marked lowering of the bone ash percentage. The irregular shaped, uncalcified areas are known as interglobular spaces and are of quite frequent appearance in human teeth, many of them being present where the tooth developed during a period when calcium and phosphorus and vitamin D were lacking in the individual in question.

From the observations made to date on these and other sections ground out in this laboratory, it seems evident that at about 40 percent bone ash and above, the dentin of the incisor tooth of the rat forms within the range of normalcy but below 40 percent bone ash evidence of poor dentin calcification becomes increasingly apparent as the bone ash decreases.

The report on the condition of the dentin of the mandibular incisor teeth of experimental rats fed milk from cows at Randleigh Farm under various conditions of feed and irradiation in 1936 is given herewith:

The Research Laboratory of the Dental College, Ohio State University, received from Dr. J. F. Lyman the heads of three different lots of white rats which had been fed by him according to the plans for 1936. The first lot, which we have designated as lot "A", consisted of eight rats divided into four groups of two each. The test on these was started January 2, 1936, and for 13 days the feed was only the Steenbock rachitic ration. Then for the following 47 days there was added to this ration five cc. of milk from the different groups of test cows. Group I received milk from cows fed irradiated yeast in addition to a usual basic ration. The condition of the dentin of the No. 1 animal of this group is shown in Figure 5 and is representative of the result of this feeding. The earlier part of the dentin (A) suggests by its irregularity some difficulty in recovering from the effects of the rachitic diet but the latter part (B) is well calcified and quite normal.

Group II of lot "A" received milk from cows on the usual basic ration and represent a control group. Figure 6 is a photograph, enlarged, from animal No. 2 in this group. While the dentin formed during the latter part of the test period (B) is quite normal, the period of recovery (A) from the rachitic diet appears to have been longer than in Group I.

The third group of lot "A" had milk from cows fed irradiated yeast and the cows themselves were irradiated in addition to the usual basic diet. The dentin of rat No. 1 of this pair is pictured in Figure 7. There is slight evidence in the oldest part (A) of this dentin of calcification difficulty which was soon overcome and the rest of the formation (B) is of excellent appearance.

The fourth group of lot "A" was fed milk from cows which were irradiated in addition to their usual diet. The dentin of the No. 1 rat is shown in Figure 8. The earliest formed part (A) indicates a longer period of recovery from the effects of the Steenbock diet than in the case of Group III but a quicker come-



FIGURE 5. Section of the mandibular incisor of rat No. 1, Group I, Lot "A". The earlier, or older part of the dentin is shown at A, and the letter B indicates the latest, or newer growth, made under the milk feeding.



FIGURE 6. Section of the mandibular incisor of rat No. 2, Group II, Lot "A". The dentin formed during the recovery from the rachitic feeding is indicated at A. Dentin formed later and showing the effect of the control milk is indicated by B.

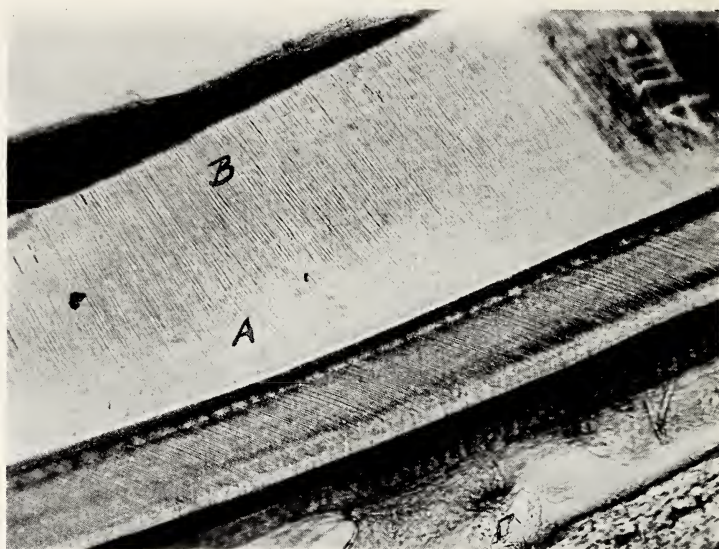


FIGURE 7. Section of the mandibular incisor of rat No. 1, Group III, Lot "A". The area of calcification difficulty in the early growth is shown at A. The newer dentin shown at B is of uniformly excellent calcification.

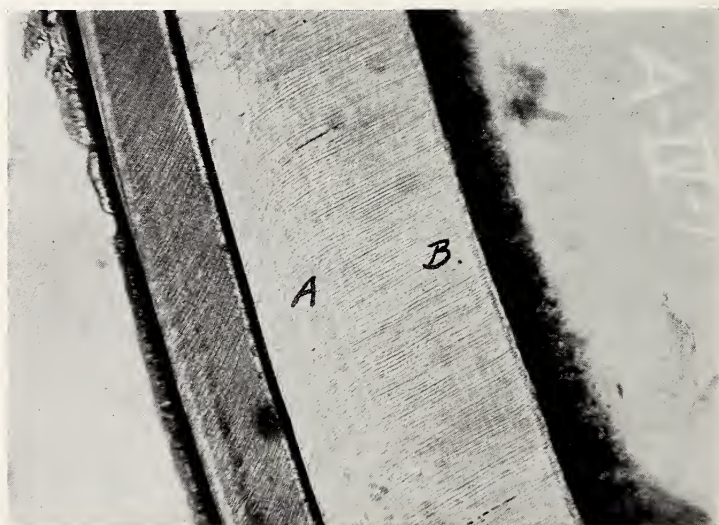


FIGURE 8. Section of the mandibular incisor of rat No. 1, Group IV, Lot "A". Dentin formed during period of recovery from rachitic diet indicated at A. Dentin of later formation shown at B.

back than in control Group II. The later dentin in this case (B) is just as normal as the others.

The second lot of rats, eight in number and designated by us as lot "B", were started on March 10, 1936, and fed the Steenbock ration but in addition to this had five cc. of milk over the entire period of 59 days.

The milk in the first group was from irradiated cows. The dentin of No. 1 animal of Group I, lot "B", is shown in Figure 9. Unfortunately in grinding out this section it was allowed to dry and air entered into the minute tubules of the dentin. However, careful observation under the microscope shows the calcification of the dentin to be quite normal.

The second group of rats in this lot received milk from the control cows. The dentin of No. 2 animal is shown in Figure 10. The earlier calcification (A) of the dentin is not so uniform as that of the later test period (B) which is quite within the normal range.

Group III, lot "B" was fed milk from cows which received irradiated yeast in addition to the usual diet, and the cows themselves were irradiated. The dentin of the No. 1 animal of this group is shown in Figure 11. The calcification of this dentin is normal.

It is regretted that the sections of Group IV in this lot were lost in the process of grinding and hence no statement can be made about them.

The third lot, "C" lot, of rats, 28 animals in all, were started March 10, 1936, on the Steenbock rachitic diet alone and kept on it until the following April 4th. Then in addition to the rachitic diet they were fed five cc. of milk for the next 34 days.

Group I were fed milk from the irradiated yeast-fed cows. Illustrative of the condition here the dentin of the No. 1 rat is shown in Figure 12. The effect of the rachitic diet in the earlier dentin (A) is quite marked but the dentin formed after the recovery (B) is very good in quality.

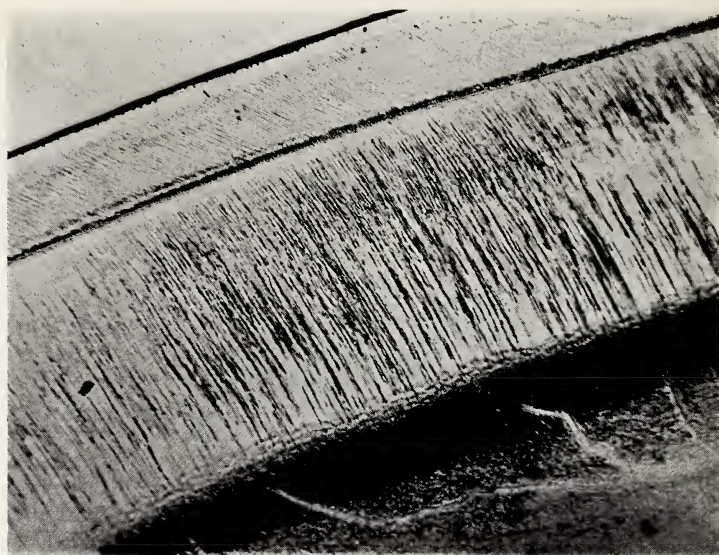


FIGURE 9. Section of the mandibular incisor of rat No. 1, Group I, Lot "B". Air in the dentinal tubules shows black and masks the structure.

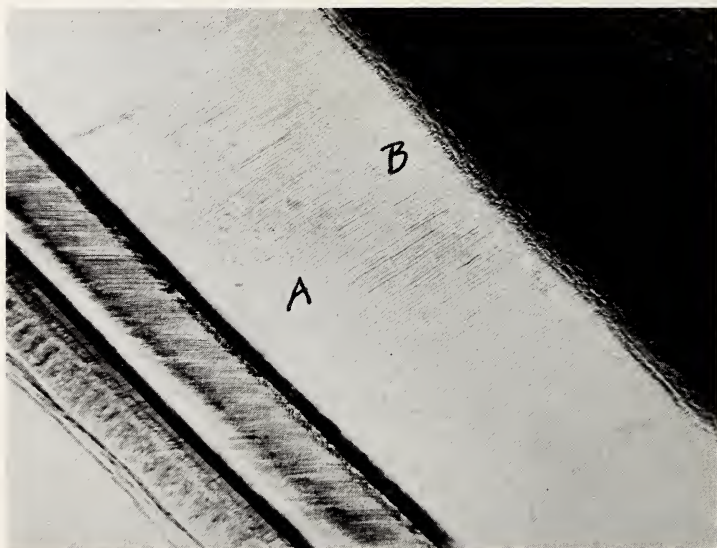


FIGURE 10. Section of the mandibular incisor of rat No. 2, Group II, Lot "B". The earlier calcification (A) is not so uniform as that of the later period (B).

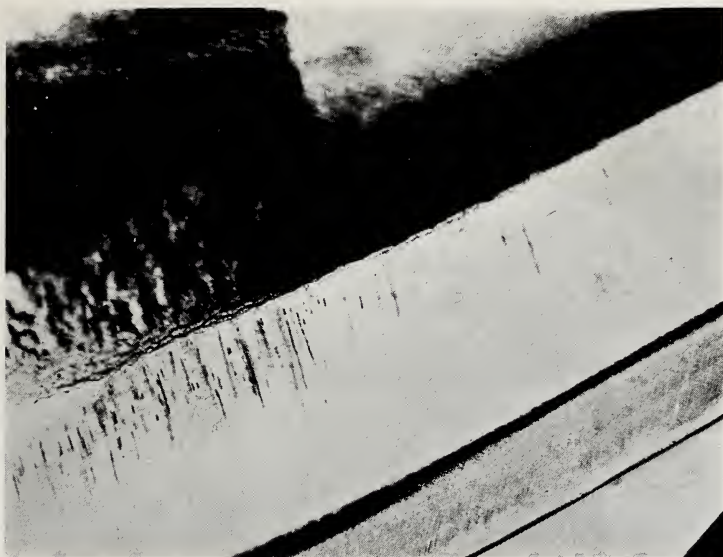


FIGURE 11. Section of the mandibular incisor of rat No. 1, Group III, Lot "B". The calcification is normal.

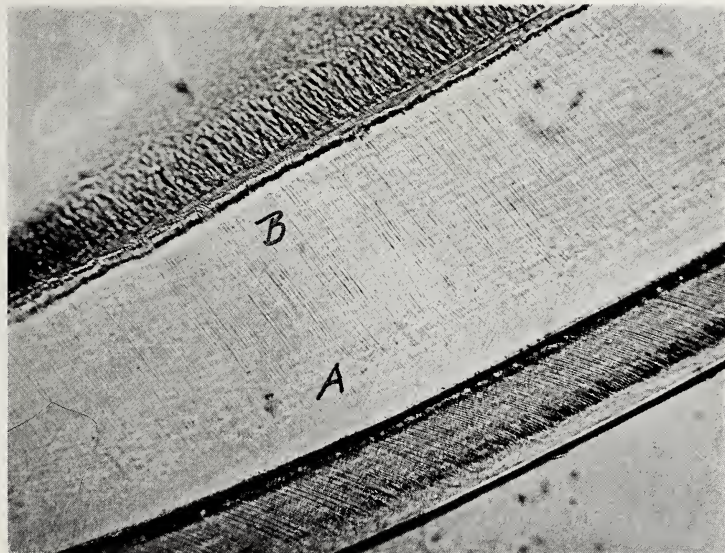


FIGURE 12. Section of the mandibular incisor of rat No. 1, Group I, Lot "C". The effect of the rachitic diet is quite marked at A. Dentin formed after the recovery from this diet and during the milk feeding (B) shows very good calcification.

The control group fed on milk from cows on the usual diet of Randleigh Farm is illustrated in Figure 13. This is a photograph of the dentin of rat No. 2. There is no essential difference over the dentin illustrated in Figure 12.

The third group of lot "C" received milk from cows that were both fed irradiated yeast and were irradiated. Here also the effect of the period on a rachitic diet is evident in the earlier dentin formation (A). The newer dentin (B) laid down during the addition of the milk is very evenly calcified. The dark spots and what appear to be irregularities in this newer dentin are really debris in the mounting medium around the section. Figure 14, a photograph of the dentin of rat No. 2 of this group, illustrates the condition in this case.

The last or fourth group in lot "C" received milk from cows which were irradiated in addition to their usual diet. The dentin of rat No. 6 is shown in Figure 15. Here as in the others of this lot the damage of the Steenbock ration is quite apparent in the earlier formation (A). The dentin formed during the milk feeding (B) is quite normally calcified.

In conclusion, it may be said that the teeth illustrated are representative of the animals examined and that in practically all the sections the dentin formed during the latter part of the milk feeding was well within the range of normal. The indication is, therefore, that the milk from the control group of cows was sufficiently high in minerals and vitamin to produce good tooth structure in rats to which it was fed; and while the feeding of milk from irradiated and irradiated yeast-fed cows seemed, in some cases at least, to overcome more quickly the effect of preceding rachitic diet, once that result was accomplished the remaining dentin calcification was not consistently better than in the case of the milk from the control cow group.

In order to carry on the research work outlined above it has been necessary for us for the last three years to forward to Columbus, Ohio, each day from December to May 1, six quarts of different kinds of milk. These were shipped three in a



FIGURE 13. Section of the mandibular incisor of rat No. 2, Group II, Lot "C". The dentin formed by the feeding of the control milk looks just as good as does the dentin shown in Figure 12. Even the recovery period here (A) seems as short as in the preceding photograph (Figure 12).

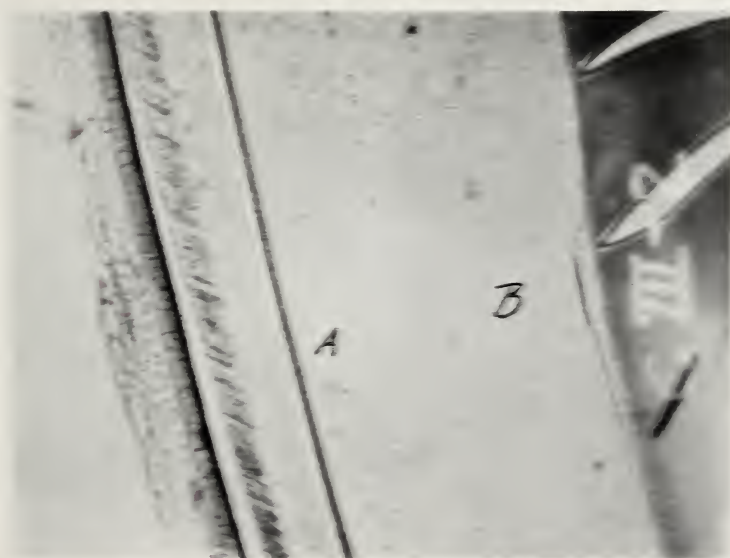


FIGURE 14. Section of the mandibular incisor of rat No. 2, Group III, Lot "C". The period of rachitic diet is shown at A and the dentin laid down during the milk feeding as indicated at B. Dark spots and apparent irregularities in the newer dentin are really debris in the material in which the section is mounted.

wooden container, which was lined with two inches of cork. After many tests we have concluded that the cream spread containing approximately 70 percent of fat, made from the different kinds of milk, gives equally satisfactory results when fed to chickens and white rats. Therefore, the winter of 1936-37 will necessitate the shipment of cream spread once each week only. (Of course, it is mixed with water before being fed.)

During November, 1936, again we had a conference at the farm with Professor Erf, Dr. Lyman, Dr. Kitchin, of Ohio State University, and Dr. Inman, research head of Antioch College, Yellow Springs, Ohio. This conference lasted the better part of two days and we concluded to continue the experiments as formerly except that Dr. Inman will assist us in the determination of the vitamins and also the percentages of carotin, chlorophyll and xanthophyll in all of our feeds as well as in the milk.

With the cooperation of E. R. Squibb & Sons, New York City, D. G. Perkins, sales manager, Veterinary Products Division, came to the farm, and together we planned and expect to carry out some interesting experiments with cod liver oil (Exadol A), Vionate Navitol and other products made by them.

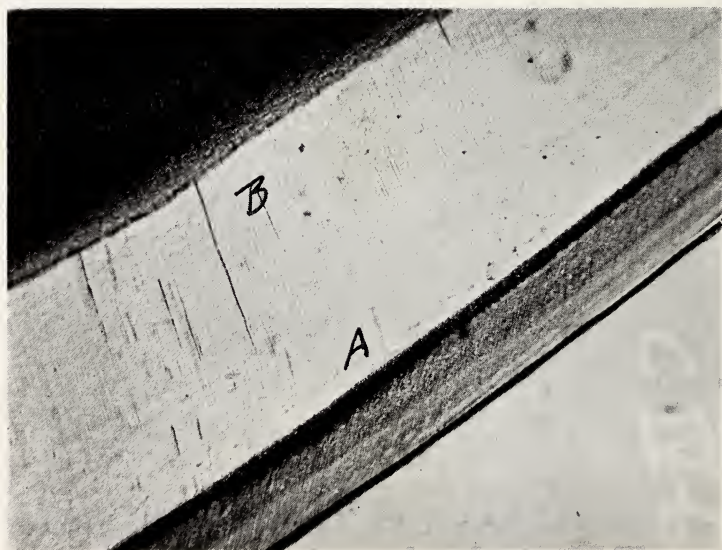


FIGURE 15. Section of the mandibular incisor of rat No. 6, Group IV, Lot "C". The defective dentin due to the Steenbock ration is quite apparent at A. The newer dentin formed during the milk feeding (B) is normally calcified.

CHAPTER XIV.

WHAT ARE VITAMINS?

VITAMINS are found in foods in minute quantities and are indispensable for health and growth. They are protective food factors. It was thought at first that possibly only one kind of vitamin exists. From time to time different types of vitamins have been discovered; six vitamins are now recognized, named A, B, C, D, E and G, and recently P has been added. Numerous investigators have studied this subject of vitamins since their discovery in 1909, which has resulted in their isolation, identification and even synthesis.

Vitamin A promotes growth, general good health, resistance to disease, and fertility; and it aids in preventing colds and germ infection. It contributes to general body vigor and can be stored for future use. It is a tissue-building substance, stored principally in the liver. A lack of vitamin A in the body results in eye diseases, stunted growth, lack of resistance to infection of mucous membranes, and tendency to formation of stones in kidneys and gall-bladder.

The richest sources of this vitamin are the fish liver oils, and of these halibut liver oil is the most potent. It is also supplied by milk, butter, egg yolk, fresh cheese, green vegetables, carrots, yellow corn and dehydrated hay.

Vitamin B is the anti-neuritic vitamin, necessary to normal digestion, sound nerves and natural sleep. It is specific in cases of loss of appetite, subnormal temperature, fatigue, loss of weight and vigor, emaciation, malnutrition and constipation. It increases milk production in dairy cows. Its splendid results in cases of neuritis have been fully demonstrated. It prevents inflammation of the nerves. Small portions of this vitamin prevent the disease known as beri-beri, a degeneration of nerves.

Yeast and germ of wheat are the richest source of this vitamin. It is also furnished by cereals, milk, liver, grapefruit, lemons, spinach, lettuce and raw peanuts.

Vitamin C prevents irritability, lack of stamina and retardation of growth in children. A lack of vitamin C in the body results in scurvy (which is a breaking down of the inter-cellular substances, especially in the capillaries), pyorrhea, tooth decay, tendency to generalized hemorrhage, reduced hemoglobin and heart palpitation. This vitamin as ascorbic acid prevents oxidation of milk and also helps to build bone.

Vitamin C can be obtained in large quantity in germinated grains, and citrus fruits and, in lesser degree, from tomatoes, raw cabbage and lettuce. It is the only vitamin whose efficacy is decidedly impaired by cooking.

Vitamin D prevents rickets and brings about proper deposition of lime salts which construct bones and teeth. It can be produced by ultraviolet rays acting on a substance called "ergosterol" ("viosterol") after absorbing the beams of light and energized. A number of foods and the skin of human beings and animals contain ergosterol. This vitamin is also found in yeast after raying. It may be supplied by liver, cod liver oil, egg yolk, cream, milk, and sunshine.

Vitamin E is called the "anti-sterility vitamin," affecting the so-called "life system" of the body. Experiments have shown it to be essential to reproduction in both sexes. Its best sources are germ of wheat, lettuce leaves, egg yolk, meat, rolled oats and yellow corn. It is not so abundant in milk.

Vitamin G is best known as a preventive of pellagra, which is the scourge of many southern states. This disease affects digestion, skin and nerves, and if uncontrolled, leads to mental derangement. Deficiency of this vitamin causes alimentary disturbances, dermatitis, pigmentation and thickness of the skin, soreness and inflammation of the tongue and mouth, and diarrhea. It possesses growth-promoting properties essential to man and animals and is found in greatest volume in milk and yeast.

Vitamin P prevents purpura by improving the tone of the endothelial cells of the capillaries and possibly assists platelet formation.

CHAPTER XV.

THE CONTROL OF MASTITIS

IN OUR operations we have been constantly on the watch for any condition in the herd which might affect in any way the sanitary quality of our milk. An important problem at present is mastitis or garget. I am sure that a large number of herds are so infected but their owners are not aware of it. The cow apparently may be in normal health and the milk normal in appearance, and yet the udder may be infected. The only outward indication of the presence of mastitis may be an occasional bad quarter. When these infected quarters are found, even though the condition clears up, the presence of the infection remains in the herd; and some method of detection and isolation should be put into practice.

To control mastitis in milk and as a means of detection, we installed, September, 1932, two strip cups which we use once each day (just before the night milking). Further, during the early spring of 1934 we commenced using Chardin Paper (Arthur H. Thomas Co., West Washington Square, Philadelphia) and the entire milking herd is tested once each week. Later we used Bromthymol Blue test (also called Thybromol) once each week which appeared to be much more accurate. It consists of an indicator solution which, when added to milk, gives a green to blue color when the quarter is infected, and a greenish yellow color when the milk is normal.

Possibly the most effective method would be to have a drop of milk from each teat put on a test blotting paper just before attaching the teat cups. This would establish confidence in the eyes of the spectators who frequently ask: "How do you know the milk in the cow's udder is good?"

It should be noted that ordinary well water will give a blue color to the test paper. The test is not useful the first two weeks after freshening or within two weeks before drying off.

Milk may give a positive reaction during these periods when mastitis is not present. Furthermore, a leucocytic test was introduced by which leucocytes of milk are determined, as well as other contamination. Leucocytes develop in increasing numbers in blood milk or milk as soon as most infections occur. This is an additional safeguard.

Chemical and Bacteriological Tests

Recently we have introduced additional safeguards for this herd. This work for detection of mastitis was done by E. D. Hildreth, of Ohio State University, and is described as follows:

"The more common outward characteristics of the presence of the infection are: Lumpy milk, off-colored milk, presence of indurations in the udder, and the abnormal drying-up effect of one or more quarters. The use of the more delicate tests is encouraged to detect slight infection in an early state. The most common is the 'Bromthymol Blue' indicator test (described above). The limitations of this operation depend upon experience in reading the tests, stage of lactation, and application of the results.

"The test for the percentage of chloride contained in milk is recognized as one of the most accurate examinations for the presence of udder disturbance. The chloride content for normal milk is 0.10 to 0.14 percent. In the case of an infection, the chloride content is usually above 0.14 percent and may contain as much as 0.2 percent or more, depending upon the severity of the infection. This test is not useful for the first few days after freshening nor within the advanced period of drying off the cow. This work should be done by a technician trained in chemistry.

"Another examination consists of incubating aseptic milk samples for 24 hours and the subsequent microscopic observation for typical long chain streptococci. The presence of these organisms is indicative of udder infections. Further identification work may be carried on from the incubated samples.

"The three tests outlined above will determine the presence, severity, and type of infections. The health records and understanding of herd management are always helpful in the construction of a clean-up program."

All these tests have been on each individual cow at Randleigh Farm. Naturally in every herd some cows must be isolated at times, but good feeding and management for protection are always desirable and necessary. Therefore, some of these animals soon recover from their infection if properly treated, while others that do not respond are removed from the herd.

In this connection it is of interest to report the results of inspection and tests made at Randleigh Farm by a representative of the New York State Board of Health, who inspected 96 producers of certified and grade A milk.

Dr. Graves from the State Board of Health came here one afternoon and said he was making a survey of all the Special Grade "A" Raw Milk dealers of the state and asked to go over our milking cows. Immediately after milking he took samples from each quarter of each cow and tested them for mastitis. At the same time he sat down to each animal and went over the udder carefully, examining for thick quarters or anything that was not normal. The local health inspector was with him and made a record of his findings from each animal. He was dividing all cows into four classes, as follows: Class 1, cows with perfect udders in every respect. Class 2, cows with udders a little off shape but whose milk was not in any way affected. Class 3, cows that showed evidence of mastitis and should be removed from the herd and re-examined after 60 days. Class 4, cows not suitable to remain in the herd and must be disposed of.

At that time we were milking exactly 50 cows here and from this number he had one in Class 3, whose milk we had not saved for a long time. There were five in Class 2 and the balance were in Class 1. We showed him our last blood test on 99 animals, and he stated that in all his experience he had seen only one report as good.

CHAPTER XVI.

BULL EXERCISER

OUR BULLS, six in number, are kept in adjoining runways alongside one of the paddock yards used by the cows.

These runways are 50x250 feet each in size and are separated from each other by a wire fence. We thought it necessary for the bulls to be out in the open and close enough to the barns that they would see the movement of men and cows about the barn.

We found it necessary to exercise the bulls, and purchased a treadmill which we hoped would solve our problem. Unfortunately, only one bull out of the six would work it. The others simply would sit back on their haunches and we could not get them to do anything.

We next tried beer kegs filled with water weighing about 230 pounds each, rolling the kegs at the bulls in order to get them to butt the kegs around. For a while this worked splendidly. One bull got so expert that he could roll the keg to the corner of the fence, push it up vertically and get it on his horns and run the entire length of the exercising yard before dropping it. It was quite a sight! A difficulty arose due to the fact that the bulls broke them up so quickly we were unable to purchase them fast enough to meet our requirements.

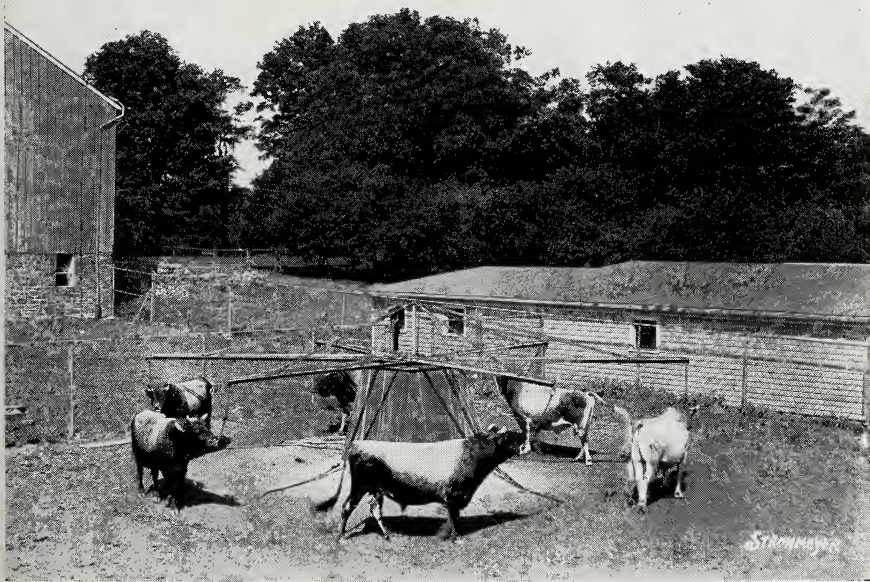
The next plan was to lead the bulls each afternoon. This required six men, and the bulls were continually jerking at the halter which made it difficult for the man leading.

We discussed the matter at some length with Professor Erf and he suggested a bull exerciser. This was constructed of steel and was manufactured by C. F. Michael, of Bucyrus, Ohio. We erected it during April, 1931. It is composed of six arms each 21 feet long, attached to a vertical shaft driven through a worm and spur gear by an electric motor. It rotates at slightly less than three miles an hour, and each bull is attached to the

end of the arm by a chain and walks around the circle for approximately two hours each day.

We have never had any trouble with the apparatus, and we are fully convinced that it is greatly beneficial to these animals. The attaching chains are about five feet long which permit of some leeway. It is interesting to note that the older bulls walk as near the center as the chain will permit while the younger bulls follow directly behind the outside end of the arm. The older bulls therefore walk in a smaller circle which means they walk slightly slower and do not walk quite so far. Thus you note these bulls have brains and use them when exercising.

We have had 10 bulls which have been in service on Randleigh Farm. We have never had the slightest difficulty with any of them and we attribute it entirely to the fact that they are taken out of their pens every day and exercised.



DOING THEIR "DAILY DOZEN" AT RANDLEIGH FARM

CHAPTER XVII.

ELECTRIC FLY SCREENS

WE STARTED some demonstrations on electric fly screens in 1931 although we did not get far that summer. During the next two summers these were carried on to a much greater extent with screens purchased from the following companies:

Insectocutor Screen Co., Sycamore, Ill.

Folmer-Chapin Corporation, Rochester, N. Y.

Cincinnati Screen Co., Cincinnati, Ohio.

The first is constructed of crimped spring wire and porcelain insulators, every other wire being of different polarity. The Cincinnati company has been using much the same idea except that their porcelain insulators are of a better design and the distance between the wires of different polarities has been increased by staggering. This, we believe, to be a feature of considerable improvement over the Insectocutor.

The Rochester screen is a blanking and drawing proposition made by taking a sheet and blanking out slots in it, leaving a narrow strip between slots to serve as a wire, two sheets placed adjacent to each other with the slots staggered, each sheet being of a different polarity. The construction of this type is admirable. For some reason we have not been able to discover, the Rochester screen does not attract flies like the Cincinnati type, although we have used it in its natural state (aluminum color), also painted black and green. Color seems to make no difference in attracting flies and we have reached the conclusion that flies are attracted by a small wire held horizontally. Apparently they make an effort to light upon it. Where the wires are placed vertically the results are not as good although it is equally as effective electrically. This was determined by building two screens, one of one-eighth inch drill rods and the other out of one-sixteenth inch wire rods, the drill rods being placed ver-

tically in two brass frames, the two frames separated so the rods would be staggered, each frame of a different polarity. The other was similarly constructed of one-sixteenth wire rods fastened to two brass frames and placed in a horizontal position with a stiffener in the center. This was much more effective than the vertical wires and attracted the flies in greater numbers.

We found that sheet mica compressed into strips about one-quarter inch thick was the best insulation. This was obtained under the trade name of "Micanite". If any moisture gets in between the sheets the insulation breaks down. Bakelite was effective until it got moist and then it burned like wood.

Our experiments covered a range of 3500 volts up to 5000 volts with approximately the same distance between the wires; the higher the voltage the more effective, but the greater the difficulty from an insulating point of view. Regardless of voltage the current on the secondary should not be over 10 amperes with a primary of 110 volts, insulation being difficult with anything over this.

We also found whenever it rained and the wind blew the rain on the screen, it was short circuited and put out of order. It became necessary to overcome this condition.

All windows and doors were screened the full height. We found from experience that the upper half of the window did not attract the flies in anything like the proportion as the lower window, and hence, we have redesigned our screens to electrify only the lower half, the upper half containing the usual bronze screen wire.

We have found that two full windows operate satisfactorily on one transformer, and in reducing the area to only the lower half we can use four windows on each transformer. The total length of all wires from one transformer, however, should not exceed 50 feet.

New Improved Screen

After several years of observations and experimenting with various types of electric fly screens, we have developed at Randleigh Farm a satisfactory screen (patent issued by the Patent Office under date of March 17, 1937, Serial No. 97,951). It has overcome the difficulties previously mentioned, and hence we are giving this detailed description and drawing of it:

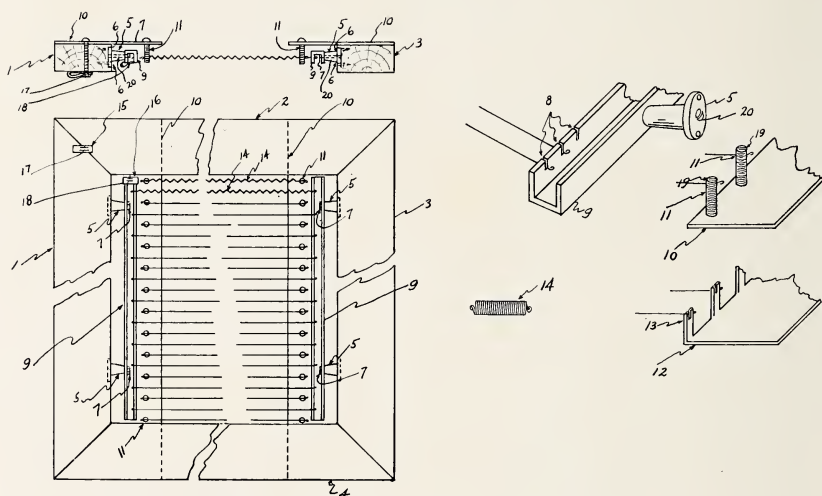


DIAGRAM OF NEW IMPROVED ELECTRIC FLY SCREEN

The screen consists essentially of three parts, a frame, a set of insulated wire holders, and a series of wires stretched between these holders, having a current of electricity passing through them. 1, 2, 3 and 4 are four members of a wood frame similar to a conventional wire mesh fly screen frame. This can be made of any other material as desired. 5 shows four porcelain insulators screwed to the edge of the wood frame by means of screws 6. In this case the insulators have been recessed slightly

into the frame, but this is not essential and does not affect the design of the screen. 7 is a nut on the end of a screw 20 which passes through the center of the insulator 5. 8 is one of a series of slots cut in leg side of channel 9. 9 is one of two metal channel sections, made of brass, bronze or any other metal having a high electric conductivity. 11 is one of a series of metal posts screwed at evenly spaced intervals into strip 10. These posts are the same material as the strip. They may be attached to the strip 10 by any other means as riveting or brazing, as long as the joint between the strip and the post is mechanically strong and makes a good electrical contact.

Instead of strip 10 with posts 11, a strip 12 can be used having one end notched and the section remaining bent at an angle of 90 degrees with the strip as at 13. In fact any means of providing a flat strip like 10 with regularly spaced posts at 90 degrees can be used without this feature.

14 is one of the series of metal wires, made of brass, bronze, monel metal or any suitable wire having mechanical strength and good electrical conductivity. These springs are formed with each end bent into a small loop, and are hard enough to provide tension when stretched open. 15 is a conventional spring terminal electrically connected to brass strip 10 by means of a screw. 16 is another spring terminal clip braced or soldered to one end of channel 9. 17 is a high tension cable leading from terminal clip 15 to one pole of a transformer. 18 is another cable leading from terminal clip 16 to the opposite pole of the same transformer. 19 is a slot cut in the end of each post 11. If strip 12 is used instead of strip 10, slots 13 take the place of slots 19. 20 is a screw passing through insulator 5 as described before.

On each side of the wood frame 1, 2, 3, 4, two or more insulators 5 are attached. On each side a channel 9 is fastened to the insulators by means of screw 20 and held securely by nut 7. The shape of the insulator and the means of attaching

to the channel may be varied without changing the design. Spring wires 14 are attached to the channel 9 by inserting one of the bent loop ends of 14 into the slots in channel 9. Each spring is then stretched until the other end loop can be inserted in the corresponding slot in the channel on the opposite side of the frame. This gives a series of equally spaced wires stretching wholly across the frame. The length of each spring is sufficient to reach from one channel to the other and leave some of the spiral in the wire as shown in 14. The tension in these partly straightened springs prevents them from sagging and touching the adjacent wire when they expand from a temperature rise. The brass strip 10 is fastened by screw or other means to the outside of the wood frame with posts 11 turned inwardly so their ends are equally spaced between the wires attached to channel 9. Springs 14 are stretched across the frame from slots 19 in posts 11 on one side to corresponding slots 19 in posts 11 on the other side. The loops on the ends of the wires prevent them from slipping out of the slots. It can now be seen that we have two sets of wires equally spaced. One set of wires is attached to channel 9 and one set of wires attached to plates 10 and 11.

Each set of wires and its attachment foundation at each end is entirely separate from the other set; and if a positive pole of a voltage transformer is attached by means of a wire 17, through clip 15 to plate 10, consequently to each wire attached to posts in plate 10, and the negative pole of the transformer through wire 18, clip 16 to channel 9 and all the wires 14 attached thereto, no current would pass because the two sets of wires do not touch each other at any point. The interspacing of the wires in channel 9 between the wires of plate 10 and posts 11 gives alternate positive and negative wires the full length of the screen. The space between wires is carefully worked out so that it is impossible for a fly to pass between them without closing the gap between the wires, thus closing the cir-

cuit, the body of the fly acting as a current carrier between the adjacent positive and negative wires. The transformer changes the current from a primary of 110 volts lighting line to 2500 to 5000 volts secondary at 8 to 10 amperes. This will electrocute any insect through which it passes. On account of the condenser effect of the two brass plates forming one polarity on the front side of the screen it is recommended that 3500 volts be used as this seems to give satisfactory results. The wires are inserted in separate pieces and can be removed one at a time, so if because of any mechanical injury, it is easily replaced, or can be removed without disturbing the operation of the balance of the screen.

This screen will stand a driving rain without breaking down. The fly screen was suggested by Howard Ward in cooperation with many others at the farm.

After all the control of flies comes back to the elimination of breeding places for them. In other words, the manure about any dairy farm should be put in a closed sealed pit to prevent flies from getting at it, or the manure should be hauled out on the land each day. I also feel that each stall should be cleaned out at least twice a day and the manure removed from all the houses twice each day and no manure left to accumulate around the paddocks. This is the most effective way to control the fly difficulty.

CHAPTER XVIII.

FARM HELP

THE QUESTION of help at the farm has never worried us in the slightest. As a matter of fact, we have a greater number of applications than we are able to accommodate; therefore, we believe we have the best boys and the best milkers available. All these men reside on the farm in five dwelling houses and one boarding house for single men. In addition to this two men room over the herdsman's office attached to the test barn and three men over the calf barn. The object of this is to have someone in both barns all the time.

The enthusiasm, energy, efficiency and loyalty at the farm have been outstanding. I have never heard anyone say the work was hard or he did not have time to perform it. The quality has been much beyond the average and appears to be improving. The demand for work from young college boys seems to be unlimited.

As in illustration of just what our experience has been in connection with labor I am glad to detail two experiences, which to my mind convey the opinion generally accepted by people interested as to just what class of work we are doing here:

Several years ago, about the middle of the summer, I was at the farm and a prominent New York railroad lawyer and his wife came to the farm (I having known these people in the railroad world for a good many years); and with much surprise at seeing them, I asked how they happened to be here. He immediately said his errand was to see his son who had been at the farm since the fall prior. It seemed this young man graduated at Amherst, took an agricultural course and, desiring to get some practical experience, came with us for the purpose of remaining one year. He was an excellent individual, talented and apparently in earnest as to what he proposed to do.

On another occasion about the middle of December I was alone in the office at the farm. A Saxon-haired young man with a suitcase came into the office and asked if I was connected with the institution. Upon inquiry it developed he was in quest of a job. I stated that during the summer we did not object to doubling up men in sleeping quarters but we never did apply that principle during the winter; that I did not think there was any chance of giving him employment. He stated he was not interested in compensation, but was after information and experience; that he came from San Francisco with a positive intention of staying at the farm at least a year. It developed that he graduated at Berkeley the previous June; that his father purchased for him a 100-acre farm, stocked it with 30 head of purebred Jerseys; he had been trying to operate it since that time, but concluded he had to have some practical experience, and learning through the *Jersey Bulletin* of our operation individually decided without any discussion with other people that Randleigh Farm was the place to get the information and experience he required.

CHAPTER XIX.

CLASSIFICATION OF HERD

ON SEPTEMBER 16, 1935, the American Jersey Cattle Club classified our herd composed of 89 head, the judges being Prof. J. B. Fitch of Minnesota, Prof. S. M. Salisbury of Ohio, Prof. G. C. White of Connecticut and Prof. O. G. Schaeffer of New York, the results being as follows:

1 Excellent
9 Very Good
39 Good Plus
31 Good
8 Fair
1 Poor

It is to be noted that the one poor animal was a two-year-old and undeveloped. We are in hope that she will mature properly, and of course, can be reclassified up to and including five years of age. It was our hope that this herd would be classified in the early spring, as since that time they have run on pasture, being out in the sun and rain, and necessarily were not as smooth nor carried as much flesh as they did during the early spring. Suffice it to say, however, that we did nothing whatsoever in the way of fitting these animals for this classification.

Lynn Copeland, head of the Registry of Merit Department, American Jersey Cattle Club, covered this event in an article published in the October 9, 1935, issue of the *Jersey Bulletin*. We quote it in full:

Randleigh Farm Jerseys have been synonymous with production ever since W. R. Kenan, Jr., began carrying on after the Hood Farm dispersal in 1923. It was Mr. Kenan's intention to continue to develop and improve the Sophie Tormentor strain of Jerseys. In accomplishing this, a limited amount of other blood has been added, notably through Darling's Jolly Lassie, Imp. Dairylike Madcap and Killingly Torono Lass. Sons of these three noted cows are now in use in the herd in

addition to other well-known sires of pure or nearly pure Sophie Tormentor breeding.

During this period of time, cattle tested at Randleigh Farm have broken two national records and have won a total of seven Medals of Merit, 55 Gold Medals and 77 Silver Medals. Actually at the present time there are in the herd four Medal of Merit cows. The herd consists of 83 cows and six herd sires. Fifty-three of the cows have already completed Register of Merit records, 46 of this number have actual records above 500 pounds butterfat, 32 have completed actual records of over 600 pounds butterfat and 19 have actual records of above 700 pounds butterfat.

Now the herd has been officially classified for type under the classification program of the American Jersey Cattle Club. The inspection was made on September 16. Due to the large number of cattle to be classified and to the widespread interest in the herd, it was felt advisable to use several judges. Consequently, the classification was made by Prof. J. B. Fitch, Prof. S. M. Salisbury, Prof. O. G. Schaeffer and Prof. G. C. White, working together. Eighty-nine head were rated including the 83 cows and six herd sires. A summary of the entire classification showed one rating as "Excellent", nine qualifying as "Very Good" and 39 as "Good Plus". There were 31 rated as "Good", eight as "Fair" and one as "Poor".

At present the herd consists mainly of the progeny of three sires, Sophie 19th's Victor 171861, Randleigh Farm Pogis 202160 and S.'s T.'s Floss' Duke 216516. The first of these, Sophie 19th's Victor, as is well known, is a son of the immortal Sophie 19th of Hood Farm. He was purchased by Mr. Kenan at the Hood Farm dispersal sale and for years was the head of the herd. Since he has been dead for some time, his remaining progeny in the herd are now getting along in years and all are mature cows. Sophie 19th's Victor has qualified as a Gold and a Silver Medal bull and is a Tested Sire. His 53 tested daugh-

ters have a mature 365-day equivalent production of 727.51 lbs. butterfat. Fifteen of his daughters and four sons were classified. Nine of the daughters rated as "Good Plus", four qualified as "Good" and two as "Fair." All of the four sons are being used in the herd. One rated "Very Good," two qualified as "Good Plus," and the fourth one rated "Good."

The second bull, Randleigh Farm Pogis 202160, was also purchased as a calf from Hood Farm. He was sired by Pogis 99th of Hood Farm 94502 and his dam was the Gold Medal cow, Sophie's Agnes' Granddaughter 449208. Unfortunately Randleigh Farm Pogis is no longer living but a total of 15 daughters is still in the herd. These were all classified, one rating as "Very Good," eight qualifying as "Good Plus" and the remaining six on the basis of their conformation rated as "Good." Randleigh Farm Pogis is also a Gold and Silver Medal bull with a total of 22 tested daughters. The records of these 22 daughters when computed to a mature 365-day equivalent are exceedingly high, the average being 752.34 lbs. butterfat, 13,367 lbs. milk with an average test of 5.63 percent. One of his daughters, Randleigh Farm Garnet 773617, is at the present time the national champion junior three-year-old for butterfat in the 305-day division with a record of 821.56 lbs. butterfat, 14,666 lbs. milk. She was classified as "Very Good." Very little selection was done in testing his daughters for he only has 32 registered daughters and of this number just 29 have reached the age of four years. This shows that over 75 percent of the daughters over four years of age have been tested for production. The classification of his progeny thereby completed the final requirements for Randleigh Farm Pogis to qualify as a "Superior Sire" and he becomes the sixteenth bull of the breed to reach this pinnacle of accomplishment.

A third bull, S.'s T.'s Floss' Duke 216516, has had a checked career. He was also sold in the Hood Farm sale but was purchased as a baby calf by J. N. Martin of New Providence,

Iowa. Little was heard of him until in 1929 Mr. Martin entered his herd on Herd Improvement Registry test. His herd average for the first year was 482.84 lbs. butterfat and most of the herd was made up of young daughters of this bull. In fact he was one of the first sires to be definitely proved through the Herd Improvement Registry and on the basis of his daughters' records was purchased by Mr. Kenan and brought to Randleigh Farm where he is still in active service at almost 13 years of age. S.'s T.'s Floss' Duke has just qualified as both a Gold and a Silver Medal bull. He now has a total of 16 daughters that have completed their records and a number of others are on test at the present time. The average production of his 16 daughters computed to maturity is 710.98 lbs. butterfat. Here again little if any selection has been made in the testing of the daughters either in Mr. Martin's herd or by Randleigh Farm. Fourteen daughters were classified. One daughter rated as "Very Good," four qualified as "Good Plus," seven were rated as "Good" and the remaining two as "Fair."

The remaining cows in the herd are by a number of different sires, including some of the younger herd bulls. Among these are D. J. Lassie's Victor 300736, Sophie 19th's Victor 77th 323278 and Sophie 19th's Victor 71st 300732. D. J. Lassie's Victor is a son of Sophie 19th's Victor and is out of Darling's Jolly Lassie 435948. This cow in addition to her outstanding production of 1,141.28 lbs. fat as a junior four-year-old, has proved herself to be a remarkable transmitting dam. She has three daughters in the Randleigh Farm herd and every one of the three has qualified as a Gold Medal cow, two of these daughters were rated "Good Plus" and the other one as "Good." The son, D. J. Lassie's Victor, was personally rated "Good Plus." Four of his daughters were classified, two qualifying as "Good Plus," one as "Good" and one as "Fair." The two qualifying as "Good Plus" have both completed records and both qualifying for Silver Medal Awards.

Sophie 19th's Victor 77th 323278 was also sired by Sophie 19th's Victor and he is out of the national champion producer, Killingly Torono Lass 508624. He qualified as "Good" and has nine daughters in the herd. One daughter rated "Very Good," one qualified as "Good Plus," four received ratings as "Good" and the remaining three qualified as "Fair." To date just two of the daughters have completed Register of Merit records. One, Randleigh Farm Komadge 989737, earned a Silver Medal and incidentally she is the daughter which rated "Very Good." The other tested daughter, Randleigh Farm Kewpie 989736, produced 683 lbs. fat as a junior two-year-old but unfortunately did not meet the calving requirements.

The other young sire, Sophie 19th's Victor 71st 300732, is likewise by Sophie 19th's Victor and his dam is Sophie's Korelia 533566, a daughter of Pogis 99th of Hood Farm 94502 with three records over 800 lbs. fat. Just one daughter of Sophie 19th's Victor 71st has finished her lactation and this one qualified for a Silver Medal. Seven daughters and one son were classified. One daughter rated "Very Good," two qualified as "Good Plus," three as "Good" and one as "Poor." The son qualified as "Good Plus." This son, Madcap's Victor of R. F. 337385, is out of Imp. Dairylike Madcap 646111, who formerly held the record for imported cows with the production of 960.72 lbs. fat. No daughters of Madcap's Victor were old enough to be classified.

There were many other outstanding cows in the herd sired by different bulls and it is impossible to mention all of these. One of them, Carmel Rozelle 816263, happens to be the highest record daughter of Design's Fern Oxford 287623, having a Gold Medal record of 812.55 lbs. butterfat. This cow was classified as "Excellent." Another cow, Sybil's Karnak 555563, nearly 14 years of age, is one of the last surviving daughters of Sybil's Gamboge 174663. She rated "Good Plus." Then there was Killingly Torono Louise 543422, past 13 years of age and with

two Medals of Merit to her credit. She was classified as "Good Plus." Killingly Owl Sally 580709, over 12 years of age and a Gold Medal cow, rated "Very Good."

The other national champion in the herd, Randleigh Farm Idelia 909924, leads all the senior three-year-olds in the 365-day division with her yield of 1,050.32 lbs. of fat. She is a daughter of Sophie's Agnes Laddie 179327, a former herd sire, and was classified as "Good Plus." There were two other daughters of Sophie's Agnes Laddie in the herd, one rating "Very Good" and the other as "Good." Golden Glow Sophie Rose 676138 with a Gold Medal record of 817.95 lbs. fat was classified "Good Plus" at nearly 13 years of age. She is a granddaughter of Vive La France, being sired by Vive La France's Darling Son 171139. Finally, a new addition to the herd, Reine Du Monde 1037667, was classified as "Very Good." This cow is a daughter of Sourette's Fern Oxford, out of the same dam as Brampton Reine du Ciel.

It has been of especial interest to compare producing ability with type as determined with the classification program. Since nearly all of the cows classified in the herd had completed production records, the following table was compiled showing the average of the actual fat records and also the average mature 365-day equivalent production of all the cows classified in each class. A glance at this table will show that in the Randleigh Farm herd as in nearly all the others there is a definite correlation between the type classifications and the producing ability of the cows.

AVERAGE RECORDS OF ANIMALS CLASSIFIED

Rating	No. Cows Classified	Cows with Records	Av. Yield Actual Lbs. Fat	Av. Yield Records Computed to Mature 365 Days, Lbs. Fat
Excellent	1	1	813	813
Very Good	8	6	720	930
Good Plus	36	30	659	818
Good	29	13	610	799
Fair	8	3	561	762

Mr. Kenan and the manager, T. E. Grow, certainly deserve a world of credit for the outstanding contribution they have rendered to the Jersey breed in helping to perpetuate and improve the Sophie Tormentor strain, a strain which is generally recognized as being as pure for the character of production as any strain or family within the entire breed. With the background of records completed and the information gained through classification, Randleigh Farm is expected in the future to contribute still more to the progress of the breed.

CHAPTER XX.

MINERALS AND THE DEVELOPMENT OF THE SOPHIE TORMENTORS

Oscar Erf

THE TENDENCY of the progressive dairyman is gradually to develop a herd of cows with large milk and butterfat production with as near 100 percent reproduction as possible, and a low percentage of replacement. The feeding and treatment should prolong the cow's life to a reasonable extent and should not produce a pathological condition.

Due to the heavy drain on the body of the cow when she is a large producer, her feeding becomes more complicated. Feeding cows for body maintenance or low production is a simple matter. In fact, the cow can even take care of herself if allowed to roam in the wilds; but our cattle have been domesticated and they now depend upon man for their existence. Dairy-men with the aid of scientists discovered long ago that protein, carbohydrates and fats are essential factors; and we soon found ways to supply them in abundance, largely through concentrates or by-products of industries.

Little did we recognize the value of increasing the protein of hays. We had, however, observed the value of minerals in hays as early as 1897. Little was known at that time about minerals as a necessity in the ration, and practically no attention was given to them in feeding operations.

The Importance of Minerals

Our first observation came through the experience of feeding a whey residue after milk sugar was removed. This product, which consisted largely of milk ash, gave such favorable results that we began to give minerals more consideration. We soon discovered that while some minerals gave favorable reactions as foods and catalytic agents, others acted as depressants and produced unfavorable conditions. It, therefore, became important that we develop a combination of minerals which would

bring about a consistent improvement in cows year after year. This work has now been going on continually for nearly 40 years.

Minerals are nearly always the natural constituents of feeds, but they vary in amounts, depending upon the kind of soil on which the plant is grown. There has always been an advantage in feeding minerals in this organic form. However, there has been a long controversy as to whether feeding inorganic minerals is not practically the same as feeding the same minerals synthesized in plants. In reality, some minerals are fed more economically in the inorganic forms than in the plants and with equally beneficial effects on the cow if the proper accompaniments are supplied.

Such minerals as calcium and phosphorus must be fed in comparatively large amounts through hays or forages, which contain the associated factors, namely, the enzymes, chlorophyll, carotin, vitamins, and other nutritional factors necessary to metabolize the minerals. There are no other mineral constituents so necessary to the high-producing cow. Milk should be one of the highest calcium and phosphorus foods for human consumption. Milk from properly fed cows plays an important part in the proper development of the child.

It is difficult to determine the effect of one individual mineral upon the body metabolism without balancing or correlating other minerals with it. Maximum and minimum amounts of some of the minerals needed for good metabolism can be only approximately determined through observation, clinical experience and by examination of the animal as to its physical condition, reproduction, and milk and butterfat production. An unusually high percentage of calcium may allow the development of rickets just as a lack of calcium may.

A Striking Family History

We have attempted to trace several problems of calcium, phosphorus and iodine metabolism and in one instance have

gone back as far as 1878. In this case, cows were imported from the Isle of Jersey, and, according to records of the old breeders, weighed on the average 700 pounds each. These animals were imported into Tennessee and were propagated on a few farms near Columbia, where the soil is especially high in phosphorus. Here we found these families not only developed into extraordinary producers, but also by inherito-environmental influence through generation after generation, gradually increased in size, weighing 200 to 250 pounds more than their ancestors when imported. We have attributed the increase largely to the crops grown on this soil because of its high calcium and phosphorus content.

The particular strain that we refer to is the Sophie Tormentor family. Tormentor was imported by Major Campbell Brown in 1879. Baron Sophie was imported by R. R. Foster of St. Louis in 1882 and went to Captain M. C. Campbell at Foster's dispersal sale. Sophie's Tormentor was bred by M. C. Campbell at Spring Hill, Tennessee. He was born early in the year 1888, his sire being Tormentor and his dam Baron Sophie. Sophie's Tormentor was purchased by Lyman A. Mills of Middletown, Connecticut, from Captain Campbell. C. I. Hood purchased the daughters of Sophie's Tormentor from Lyman Mills. Sophie's Tormentor's son, Torono, bred by Mills, was also sold to Mr. Hood. Ida Stokes Pogis, bred by Mr. Babcock of Montreal, was purchased on January 1, 1885, by Captain Campbell, Major Campbell Brown and T. H. Malone, to be used in their herds. Oonan's Pogis, whose sire was Ida Stokes Pogis and whose dam was Oonan, was bred by Captain M. C. Campbell. Oonan Pogis was the sire of Hood Farm Pogis, bred by Captain Campbell. He was sold to C. I. Hood; and a number of cows, including Tormentor Lass, bred by Campbell, were ultimately acquired by Hood Farm. Hood Farm Pogis was the sire of Hood Farm Pogis 9th and Hood Farm Pogis 9th was the sire of Pogis 99th of Hood Farm.

This breeding resume of animals, bred and developed largely on the rich phosphorus soils of Tennessee, became the principal basis of the Hood Farm breeding operations.

Soil Minerals Are Important

Both Lyman Mills and C. I. Hood had farms which produced grasses high in minerals at that time, particularly so in calcium, phosphorus and iodine; and when fed large amounts of protein, carbohydrates and fats, these cows became rather famous for extraordinary production. This mineral development became an interesting fact to Mr. Hood, the breeder, and at his suggestion, the composition of the soils of both Tennessee and the Isle of Jersey were determined and compared. It was found that feeds on the Island consisted mostly of hays and roots which contained a great deal of iodine, due to the fact that they were fertilized yearly with seaweed, naturally rich in iodine. The calcium and phosphorus of the soil on the Isle of Jersey were rather low in amount, and we wondered whether this and the high iodine content of the hay and roots did not have an influence on the size of the Jersey cattle and also an influence on the percentage of fat in the milk.

Dr. Wingate Todd, chairman of Brush Foundation of Western Reserve University, Cleveland, Ohio, contends that bone formations (especially indicated by the facial bones) are sensitive to disturbance during growth. If anything interferes with normal bone development in childhood, the appearance of the face may be altered for life. Records at the Cleveland laboratory show that faces of undernourished children are changed. A change to a proper diet will, to a degree, restore normal growth. Most of the damage has been done, however. For instance, such halted facial developments account for grown-up "baby faces." Similarly, the particular bone developments of the Sophie Tormentor family may have been due to dietary factors.

The soil on the Campbell-Brown farms in Tennessee was rich in calcium and phosphorus. Feed grown on this soil was likewise reasonably high in these mineral constituents, and the milk produced from the cows was consequently richer in minerals than ordinarily. We have found the soil throughout this portion of Tennessee high in iodine also. As nearly as we could ascertain, many of the cows fed and bred on Tennessee soil and with sufficient feed usually had good size. In the Lancier's Fancy family, this was particularly noticeable.

I do not want to leave the impression that inheritance is altered by feeding. We must, however, recognize the fact that there is a large range of variability, particularly in the digestive and lactating system of the cow, and many of the glands have an excess capacity over that necessary for ordinary life requirements. In fact, the entire animal system can be developed to an excess capacity which, to a degree, becomes normal by better feeding and care of the cow. It is true that sudden and definite variation in the composition of a cow's feed does not ordinarily alter the content of milk and the inherent milking ability. It is our observation, however, that if a special, uniform composition of feed is constantly fed for several generations, it will usually change the content of the milk and somewhat alter the character of the animal. We had noticed this particularly in feeding high iodine feeds, and we may be right in attributing the smaller size of the Jersey cow to a highly active thyroid gland which results in a higher energy output and hence less chance for body building.

We might also assume that the constant feeding of calcium and phosphorus, generation after generation, will affect the endocrines, particularly the pituitary and thyroid gland. There undoubtedly are other factors that are influential in the body. For instance, Quinto Calabro and Fernando Fantozzi (*Arch. ist. Biochem. Ital.*, 5:76, 1933) conducted tests on goats to study the effect of hormones on lactation. They observed that thy-

roid and parathyroid extracts stimulate the secretion of milk, whereas ovarian extracts inhibit it. They found, too, that thyroid and ovarian extracts increased the fat content of milk while parathyroid extract had no effect.

We have found that thyroxin and parathyroid extracts given in doses of 35 cc. increase the amount of milk. Since thyroxin is largely an iodine compound, it again shows iodine's effectiveness. We can now assume that light, which stimulates the production of vitamin D, intensifies the calcium metabolism and thus develops a stronger-boned cow. The variability of the butterfat content of the milk depends somewhat upon the ratio of milk production to body weight which seems to be largely due to the increased activity of the thyroid gland and the ovaries. With iodine feeding there is, in many instances, a rise in the butterfat content of the milk. The large size and lack of refinement of the Tormentors might also be attributed to the better feeding they experienced after leaving the Island. After purchasing the Tormentors Mr. Hood began an intensive breeding, feeding and testing program, and a large number of them became unusually high producers.

Continuation of the Work

Briefly, to summarize our contentions and review the feeding history of the Tormentors:

(1) They were bred and developed on the Isle of Jersey where the feed is very rich in iodine because of the seaweed fertilization. This we now feel makes for refinement in cattle and high quality in milk.

(2) This family, brought to a high phosphorus and calcium soil, by continuous breeding and feeding on the products of this soil, became larger, slightly less refined, and gave a larger quantity of milk, often with a slightly lower butterfat content.

(3) We do not wish to give the impression that these developments were entirely due to minerals, for correlating factors

stimulate the effects of mineral feeding. Of late years, higher protein feeds such as cottonseed meal were more abundant in that region, which was also a contributing factor.

Fortunately, Wm. R. Kenan, Jr., conceived the idea of propagating the characteristics of size and high milk production of the Tormentor family with the refinement and high quality milk of the Island families. Mr. Kenan early realized the importance of minerals. Three or four generations have been propagated, with high phosphorus, calcium and iodine feeding. Along with this feeding there has been artificial irradiation with ultraviolet light to increase vitamin D. For seven years Mr. Kenan continually fed $1\frac{1}{2}$ grains of pure iodine per day to his cows. These cows are naturally fed other minerals, vitamins and plant catalysts to correlate with the amount of protein necessary to make the great records that he has with a large number of animals.

I hope this has not left the impression that feeding is more important than breeding. It is not, but it should be realized that a correlated feeding program must be carried on with good care in connection with breeding, to attain desirable results. There is an inherito-environmental influence. It matters not how well the animals are bred; if they are deprived of necessary minerals, the character of the offspring will be changed. For example, if iodine is lacking, the offspring will (according to our experience) develop a subnormal thyroid condition which naturally changes the character of the animal. It is quite essential that the breeding operation be conducted by testing and selecting the better producers in order to carry on the desirable inherent factors.

Other important factors, such as the care of the animals by close observation and good management, must be provided. These factors in Mr. Kenan's case were amply provided for by Superintendent T. E. Grow and his competent feeders and milkers.

We are glad that Mr. Kenan is continuing the work. What the outcome of this research problem will be, only time can tell. The present indication seems to be quite favorable for increased size and greater refinement, which to a large extent is proved by the recent classification of the herd, and we already know that he has a large production of high quality milk. This is also proved by the large number of silver and gold medal records and the world records his cows have made. We must not forget that the health of the cows has been improved along with the increased production and reproduction. This is a goal that is indeed worthy of the efforts of the best dairymen. This work is looked upon with great interest by progressive dairymen the country over, and is, in my estimation, one of the most outstanding demonstrations of good feeding and breeding of dairy cattle.

CHAPTER XXI.

THE INHERITO-ENVIRONMENTAL INFLUENCE

FOR DECADES the question of inheritance vs. environment has been debated, but never can it be decided in favor of either one absolutely because both are so highly essential for greatest performance in any animal. Like the question of which came first, the hen or the egg, the debate may be a favorite indoor sport; but in the end the judges say neither can be placed first, but both are necessary for highest perfection or achievement.

That adage "Like begets like" is as old as time, and always a breeder will depend on its principle. He knows when he plants corn, he will get a corn plant; and if he specializes in hybrids, he predicts exactly the type of ear he will husk in a normal season. If he is a livestock breeder he knows when he mates two animals of pure breeding, he will get offspring of the same breed and type. He knows, for instance, that if he breeds a purebred Jersey cow and a purebred Jersey bull, the calf will have all the characteristics of the Jersey—size, color, butterfat test, even the dished face, curving horns, shapely udder, etc. And if he specializes in a family, like the Sophie Tormentors, he expects every calf to have the distinguishing traits of that strain—larger size, greater vigor, not so much refinement as in the Island type, higher milk production, longevity, etc.

From these general principles then we must assert definitely that inheritance is the first consideration. No system of management or feeding is going to develop a high-producing cow unless first of all the inherent ability for high production is bred into that animal. Most of these 200-pound or 300-pound cows can never rise much above that level regardless of feeding.

The breeder though must be more than a mere propagator of animals. Progress in the breed rests upon his ability to

detect superior animals and select them for future matings, based upon type, production of milk and butterfat, longevity and ability to reproduce. One man may enjoy temporary fame by the remarkable record of one or a few cows, but still he may contribute little to the progress of the breed. What is he doing with the rest of his herd? Is he able to maintain this high production through future generations?

Today the emphasis in testing dairy cattle is upon records for every cow in the herd—not upon some show ring record, not upon some individual cow or family, but upon each female as soon as she becomes of milking age. Furthermore, the dairy breed associations today are emphasizing long-time production, lifetime performance, rather than a sensational record for a year or two. Can the record cow keep up this pace year after year, maintaining her health, giving a healthy calf about every year, and then come back after one good record and repeat her performance?

Likewise, we have changed our standards for selecting dairy herd sires; and no longer do we place the highest rating on the bull with the most championship ribbons or even on the one with the most tested or most medal daughters. These may merely represent the exceptional opportunity that was his. Rather is his value rated today on his influence in improving the production of his daughters. There is not much value then in the old trite saying, "The bull is half the herd." If that is all he is (only one-half), then that herd will not advance far in improving its milk production. The most valuable sire is one with potency to transmit to his daughters the ability to produce more milk and butterfat than their dams.

The breeder then who makes the greatest success with his cattle will study the breed history, the history of the family or families he is breeding, the average production of the ancestry, and the conditions under which they were tested. He then will test all his heifers as they freshen and continue to have them

tested for lifetime production. Records of each bull's daughters will be compared with those of their dams, and when a superior sire is found, he will be kept as long as his usefulness will last.

Randleigh Farm Illustration

What an excellent illustration of such a breeding program is found at Randleigh Farm!

However, this is only half the story. This is no answer in itself to that old debate question involving heredity and environment. Under most favorable environment the peak of inherited ability is attainable. One might have the best cattle of his breed and yet have disappointing results if the caretaker did not understand health, disease prevention, comfortable housing, feeding and kindred factors. Proper environment then is essential if the limit of inherent possibility is to be reached.

It is not necessary that elaborate buildings and equipment be bought, but it is essential that the cow be comfortable and contented in her stable and that she be fed the necessary factors—proteins, carbohydrates, fat, minerals, vitamins, “green” of grass, enzymes, etc., and in proper balance—if she is to attain high production, maintain such a milk flow over a period of years, and raise a healthy calf every year.

Heredity and environment then are “Siamese twins” in successful dairy cattle breeding, and neither can be sustained without the other.

The records of Randleigh Farm are proof of that statement. Mr. Kenan might point with pride to the record of one cow with 1050 pounds of butterfat as a senior three-year-old, a world record; or he could pick out 10 with Medals of Merit or 23 cows in his herd above 800 pounds of fat. Still, he takes greatest pride in the statement that every cow tested for a year has averaged 648 pounds, and every one on 305-day test has averaged 544 pounds, and this includes 339 records.

Furthermore, here is an interesting study from Randleigh Farm records over a period of 14 years, showing this herd when established here in 1922 had inherent high production and that with proper environmental conditions this exceptional achievement has been maintained through succeeding generations: The table in Chapter II shows that in 1922 the 10 animals on 365-day test averaged 670 pounds of fat, with three of them heifers; while last year (1935) 14 had within five pounds the same production, with four of them heifers with first calf. A greater record was made in 1934 when 18 averaged 632 pounds fat and 11 were two-year-olds! The 305-day records show a similar trend.

Recently (January 30, 1937) we looked over 48 heifers soon to freshen at Randleigh Farm. They had been "roughed" through the summer and fall on pasture, but it was exceptionally good pasture, well fertilized, rich in the "green" factors, rich in minerals; and with reserve bodily stores these animals went into winter quarters. The owner said they were the best he had ever raised. The cows were dropping calves of good size and unusual vigor. They had a maternity shed—nothing beautiful or ornamental, just a plain shed with four stalls, but it was warm and comfortable, and above all it was sanitary. Those cows were starting off on another year's record well fortified with the essential nutritional factors afforded by pastures, green hay, sprouted grain, farm-grown grains, concentrates, minerals, vitamins, sunlight.

What a combination of rich inheritance and wisely planned environment!

An Example in Fox Breeding

These same principles hold true in any line of livestock management. May we go far afield from this subject of breeding farm animals and study for a moment this illustration which also represents this union of heredity and environment? Fox

farming is not uncommon in Ohio and in states east and north, and especially is it a profitable business in eastern Canada. The largest and most successful ranch in Ohio is that of the Peak Fur Company at Medina. Like many others in this region, it had little success in its early years, litters being small in number, pups weaklings and furs grading in the lower classes. About 200 pairs of foxes are kept at this farm. Where several years ago they averaged about $1\frac{1}{2}$ whelps per litter, last year this ranch averaged 4.8.

What made the difference? Here was the same blood as in the ranch several years previously—a good strain of silver fox of high quality when given optimum environment. Professor Oscar Erf was asked by the Peak Fur Company to be their feeding consultant, and he put into operation here the same principles exactly as mentioned for the Jersey cattle at Randleigh Farm—namely, minerals, vitamins, green feed, sprouted grain, cereals, irradiated feed, cod liver oil, etc. This increased size and vigor, made larger litters, and put quality in the pelts.

Let me quote from a letter by the manager, N. A. Vorce, which gives a climaxing statement about this improvement over a period of years in these animals:

“We have just returned from the fur sales in New York, and the Peak Fur Company’s pelts stood well out in front on the January sale at the New York auction. We took the all-time top pelt at \$390 for a full silver, which was the highest price since 1929. Our color was the outstanding feature with a decided improvement in fur quality. Of all our pelts only two showed a tinge off color. This is quite remarkable as it has not been that way with us always.

“We also had the second, third and fourth highest priced furs at \$215, \$210, and \$205. Our pale silver average on 199 pelts was \$96.72, while the market on all silvers was \$62.58. Our average for the entire production will run close to \$70, compared with a market average of \$47. We were congratulated by both the auction company and the fur trade for our wonderful color. I believe we have now found the particular combination we need in feeds, minerals and vitamins.”

It is a long ways from foxes to cows, but the principles of breeding and management underlying both industries are identical; and here is one further illustration of inherito-environmental influence, that double bond of selected breeding and wise management, or in other words, inheritance and environment.—L. L. Rummell.

CHAPTER XXII.

THE POINT OF VIEW

(An abstract of a talk by Professor Erf, given at
Lockport, New York, in 1934.)

IT IS common among dairymen to say, "There is a man that runs one of those impractical dairies. He is now spending the money that he made in the city on farming and dairying, but after a while he will have less money but a lot more experience." These statements may be true in many instances, but it is also true that some of these so-called impractical, non-profitable dairies and farming operations may become highly practical to society because they set up desirable standards and detailed operations for practical dairymen to adopt. This is true providing they are fundamentally correct either by developing a more healthful or nutritious food or by lowering the cost of production and at the same time maintain the same healthful standard of the food product. After all, the dairy business originally was developed primarily to furnish a clean wholesome food for society, assuming, of course, all those connected with the business should have a fair reward for their services.

However, competition sometimes is destructive; and unless laws and regulations are instituted to control the standard of dairy products, milk, for instance, might become so unwholesome and unclean that it becomes dangerous to society. I well remember the erection of one of these so-called impractical dairies, located in a country where the government is quite unstable. It cost 30 cents to produce a quart of milk in this dairy while the market milk was selling at nine cents per quart. A revolution started in this particular country and it was natural that the standards for milk and dairy products were abandoned. Competition forced the price of milk down, insanitary conditions began to prevail, watering and other adulterations started; and conditions became so bad that people were afraid to use milk.

The "impractical" dairy maintained its standard and price of 30 cents a quart. Due to the confidence they had established the people began to buy this milk at 30 cents a quart, while the common milk went begging at two cents and three cents per quart. So the impractical dairy soon became a profitable organization, because the public was willing to pay for a wholesome, non-adulterated product.

This simply indicates the trend of thought under these conditions and what the public will do to protect themselves. High standards of quality and purity of milk, if properly and honestly enforced, become a source of great protection, not only for the health of the consumer but also to the producer and the distributor. And while these standards provide for a reasonable, wholesome, clean milk, we must, however, be alert and aware of the continued improvement necessary to meet the new and constantly changing conditions as they affect this business. Here is where research work becomes a necessity. The results of such investigational work, if fundamentally sound, are adopted by progressive practical men. These improvements are accepted gradually as soon as competition and other economical factors permit.

Therefore some one must create improvements and develop them to a point where they can be applied to business. These developments oftentimes are difficult and expensive. There are many instances that might be cited as illustrations where the impractical becomes practical and profitable. The Wright airplane was quite impractical in the beginning—now this transportation industry is becoming practical. The same is true of the automobile. The development of insulin in its early stages seemed to be impractical to the average man and to many physicians. The basis of most progress is the result of research work followed by the gradual development of the established business.

There are various ways by which this research work can be financed and carried on to its fulfillment. Three important ones may be mentioned:

First—A private business or corporation can set up its own research department. The purpose of the department is to aid or benefit the business of the organization.

Second—State or government may set up research departments, as for example, state universities, colleges and state experiment stations.

Third—Where an individual becomes interested in a particular problem for the purpose of improving conditions purely from a philanthropic standpoint, the pleasure he gets from serving mankind is his remuneration. It is a grand and generous motive. It represents the highest type of research work in a restricted field, if the individual in charge of the work has the proper scientific conception of the problem in relation to the needs of society.

Some of these so-called impractical dairy farms may then become the most practical farms of a community, the purpose of which is not to make money directly, but to create and develop improvements to meet the new conflicts that are ever arising in any active business. This is an insuring factor to the business and fundamentally makes it prosper. It is for this reason that Randleigh Farm becomes a real valuable asset to the dairy world. The many new research problems created and developed there are available to the public, and their adoption will be as gradual as business will permit. There are few people who have the vision that W. R. Kenan, Jr., has to see into a scientific problem and attack it purely for the purpose of serving society, and furthermore he is always ready to finance the problem to its completion. For instance, the Dairy Inn with all its details of operation is an example of what has been accomplished at Randleigh Farm. This plant is already being copied

by other dairies and application of the newly developed data has been made in all parts of the United States.

A most extraordinary breeding and feeding system for cattle has been developed on this farm. As a result Randleigh Farm has one of the best producing herds of Jerseys in the world. While this development represents only a few accomplishments at Randleigh Farm it might be interesting to know that a number of research problems are now being carried out and many are being planned. In all these instances the basic motive is that this must be done for the good of mankind. Whether they realize it or not the people of Lockport are deriving a decided benefit from the operation of this farm since this highly nutritious, clean milk and other dairy products are available to them.

Breeders all over the world are taking advantage of the male calves coming from these high milk and butterfat producing cows. It is due to Mr. Kenan, owner of Randleigh Farm, that the public has the privilege of taking advantage of all these new developments. His motto is and always has been "A Clean and Better Milk Supply for Mankind." No farm can have a greater encompassing, philanthropic motive. The people of Lockport appreciate their valuable citizen and the people of the world are recognizing the valuable service he is rendering to them.

IN CONCLUSION

It might not be amiss to state that every animal at Randleigh Farm is tested frequently for every common disease of cattle and those not negative to these tests are eliminated and placed in a herd at a remote distance, and are used for breeding purposes only. I do not believe that there is a cleaner herd anywhere than the animals now at Randleigh Farm. We have been under Federal supervision for tuberculosis for the last 15 years and we have complete tests for each year. We have been making blood tests for Bang's disease for more than eight years and have also been making tests for mastitis, or garget, for many years, as detailed in Chapter XV of this issue.

Much has been done at Randleigh Farm in developing new ideas for future dairies, and there is still much to be developed. It has been and is our hope that we may make Randleigh Farm useful to mankind by constant determination of the most effective way to produce the best and most healthful milk possible. This we feel should be the goal of the dairy industry.



PART II

FEEDING DAIRY COWS

WITH SPECIAL REFERENCE TO THE
"GREEN" OF THE GRASS

*
* * *
*

By
PROFESSOR OSCAR ERF

OHIO STATE UNIVERSITY
COLUMBUS

1937

FOREWORD

IN THE PAGES which follow will be found a record of observation covering almost thirty years. With a background of practical experience in dairy production and experimentation, and close contact with many of the outstanding American dairy herds; with the author being called as adviser in the solution of many baffling situations in production as well as processing; together with the fact that he has shown a fine example of inquiring attitude and rare resourcefulness in attaining results—all have combined to develop a story that will read with inspiration and profit by practical dairymen and scientific investigators.

Many of the activities described began with assumptions that, at the time, may have seemed rather vague. Reasoning that a definite result might be possible if certain conditions were provided the problem was attacked with an open mind, the results being accepted as they came, whether they proved or disproved the original assumption.

Many of America's great breeders have contributed time and money toward the work that Professor Erf has been carrying on. His skill and his cooperation have been of such high degree that he stands alone in the minds of many, as an observer and analyst.

In the winter of 1933, at a meeting of herd owners who had benefited by his counsel, a resolution was passed unanimously requesting that he prepare a general statement of his years of observation and study so that it might be available for the dairy world at large; a statement which would present the facts of science in a popular style. It is in an effort to meet that request that the following chapters have been written.

JOHN F. CUNNINGHAM,
Dean, Ohio College of Agriculture.

PART II

FEEDING DAIRY COWS

WITH SPECIAL REFERENCE TO THE
"GREEN" OF THE GRASS

PREFACE

THE experimental work reported herewith has been supervised by the author over a period of 29 years in cooperation with a number of outstanding dairymen in Ohio, Pennsylvania, New York and other states. Thousands of cattle, both purebred and grade, have been included in these studies; and they have been handled under various systems of management, so that conclusions and observations have been drawn from an unusually extensive field of practical dairy research, supplemented in many cases with laboratory investigations and analyses. The history of these dairy problems is presented more or less in sequence as the author studied them.

Most of these cooperators are named herein, and to them all the author expresses his indebtedness and gratitude for their innumerable courtesies. Only through cooperation of such generous herd owners, who put their cattle at the disposal of the author for such studies, has this work been possible. Credit also is due L. L. Rummell of *The Ohio Farmer*, who edited the copy for this book.

The science of nutrition is still in its infancy. Trial and error methods still dominate as a line of attack in its study. Clinical appraisals and pathology are the criteria for judging feeding results. Due to the inaccuracy of many short-time experiments we must emphasize the value of clinical findings in long-time experiments and have employed them in the past, supplementing them with laboratory findings. Laboratory findings are helpful in determining the status of an animal for health records, but clinical judgment based on extensive practical experience must be the basis for an accurate diagnosis. In all our work clinical judgment was an important factor in arriving at our results, but whenever possible, the judgment was checked by laboratory findings.

Much of the author's energy has been devoted to the problem of the limiting nutritional factors encountered in high production of dairy cows and to the determination of the necessity of the various constituents that comprise a complete, healthful feed. Greater accuracy has been obtained in these determinations by working with high-producing cows which do not tolerate even small deficiencies in their rations. The physical condition of low-producing cows is not visibly affected by deficient feeding over short periods, since their bodies have stored sufficient elements to meet their low requirements.

It is our opinion, and in fact it has been proven for applied dairy science, that results obtained from a larger number of experimental subjects are more accurate for practical purpose than those obtained from a few accurately guarded subjects, assuming the results in the first class are reasonably well checked.

CHAPTER XXIII.

GREEN GRASS

SINCE man began to domesticate animals, he must have known in a general way the value of green grass as a feed. Breeders and caretakers of cattle, horses, and sheep have for generations noticed the desirable changes produced in the animals after they have been on pasture for a short time.

In only a few instances did cattle feeders know that products produced by animals while on grass were superior to those produced while the animals were on common dry feed. For many years butter made from June milk was considered by some people so superior that it was stored in firkins for winter use even though winter butter was available. Volumes have been written on the chemistry and energy production of chlorophyll, or the "green" of grasses. However, no one paid much attention to the better quality of milk produced from cows on good pasture.

Deficiency Diseases

Also, little was known of the fact that diseases are brought about by the deficiencies created through the lack of green feed in the ration. Although our attention was early brought to the fact that "green" affected reproduction, we have seen no conclusive, published evidence that green grass has any effect on reproduction. Wild life offers sufficient evidence of the stimulation of reproductive activity, but this was considered due to the warmth and sunshine of spring. However, we find in southern areas where warmth and sunshine are plentiful, that without green feed, the physiological condition of the animal is changed. This has been particularly indicated by reproductive difficulties in livestock.

In making high records of milk and butterfat production, which became somewhat common in 1908, we noticed that forcing the cow for high milk production usually caused a decided decrease in reproduction. We were handicapped then by not knowing the details which caused *Brucella abortus* infection in cattle, and we thought it might be the primary cause of the reduced reproduction. Veterinarians at the time knew little of the problems of abortion and sterility, but even then some of the more progressive investigators attributed the cause to feed deficiencies. We found that not only feeding large volumes of cellulose from dry brown hays over long periods of time interfered

with reproduction but also that the milk given by cows so fed seemed to interfere with the growth and the development of calves. Upon post-mortem examination of these cows, there apparently was no serious abnormality of the reproductive organs. The clinical evidence showed changes had been brought about through the altered method of feeding. After a good deal of experimental work we found that the missing factor was largely the "green" of the plant, and, therefore, it was primarily a case of deficiency in nutritive quality and not volume of feed.

After many years of observation and tests, we quite conclusively demonstrated that cows milked three or four times daily, kept in stanchions with little or no exercise, and fed grain abundantly with little roughage, failed in many cases to reproduce. On the other hand, cows in the field having access to plenty of green grass or plants the greater part of the year, suffered much less difficulty in regularly producing a normal calf that would remain healthy. This was especially true when the cow was fed beets or sprouted grain during the winter months. Bulls fed on dry brown or bleached hay or fodder the year round, we noticed, became emaciated and were slow breeders; and calves sired by such bulls were often quite abnormally small and weak, having anemia, and being rachitic, with susceptibility to diarrhea (gastro-intestinal disturbances) and generalized infections.

Tests at Anna Dean Farm

So thoroughly were we convinced from our clinical observations over years of experience that the "green" of the plant was essential for reproduction that we began to investigate the records for production and reproduction in the various barns on the Anna Dean Farm, Barberton, Ohio, since different barns had distinctly different birth rates. A group of 11 cows in one barn which did not reproduce normally in the second year were constantly stabled in stanchions except for an hour of exercise in the yard while the stable was being cleaned. The barn was not well lighted and cows were fed no green feed during the entire year. The roughage was silage and brown hay.

In another barn a group of 11 cows produced and reproduced normally year after year with the same grain ration. However, they were fed soiling crops when not on pasture. Besides silage and a better grade of green hay, they also had some fresh green wastes from the greenhouse during the winter months. While the milk production was practically the same in both cases the first year, in the second year

the cows that had had no green feed gave 22 percent less milk, many stopped breeding, some aborted, and those that did calve had very poor calves. The third year this group produced but one calf that was normal.

"Green" Is the Answer

A controversy started as to whether the favorable results were due entirely to the "green" that was fed or whether the unfavorable results were due to a lack of exercise, as the first group of cows were nearly always in stanchions except for the one hour exercise daily in the paddock. The other group had much exercise in the summer, but were kept in box stalls and let out for an hour each day during the winter.

We had found that cows constantly stanchioned have a tendency to become sterile after a year or more of stabling; but in analyzing the conditions, we found that some cows in other herds reproduced normally when a sufficient amount of "green" was fed during the year with no more exercise. Our final conclusion was that the lack of "green" or chlorophyll was largely the reason for these cows not breeding. The owner, O. C. Barber, was not satisfied, and so he built a barn nearly 1000 feet long with all box stalls to determine more nearly the facts with reference to the relation of exercise to green feed. It was found that both the "green" and the exercise were highly essential to large milk production and reproduction. In this barn was developed the largest number of high-producing Guernsey cows in any herd in that day. Carl Gockeral was the feeder.

Attempt to Duplicate Grass

It was during 1914 that we tried to duplicate green grass pasturing by feeding during the winter months a feed in which the protein was mineralized and activated with enzymes found in germinated grain. At the suggestion of Professor H. A. Weber, formerly in charge of Agricultural Chemistry of Ohio State University, who then was the best authority on germinating or malting grain and enzyme effect, we proceeded to feed in a simple way some of the important minerals we had found in green feeds, mixed with the protein feeds and germinated grains which furnished the enzymes. It was known that the diastase enzymes would break down starches into glucoses.

Since we found glucose in young grass, it was thought that a short-cut method could be developed by feeding glucose directly to the cow. We realized the process of breaking down starches into

blood sugar requires considerable energy before it is completely metabolized and so it was thought all this could be saved by the cow and consequently she would be capable of giving more milk. Apparently our supposition was incorrect, for cows fed sprouted grain produced more milk than those fed glucoses. The process of breaking down starches in the cow produced some other nutritive factor which assisted in the process of digestion. We know now that there are many unknown factors in sprouted grain that function similarly to green grass; and while this method of feeding is not a complete substitute for green grass, it does however approach it.

The value of these methods of feeding has been demonstrated since with many other test cows in increasing and maintaining the flow of milk, which is a result of inherito-environmental influences. In each succeeding generation not only have the cows increased in quantity of milk but when such milk was fed to calves and rats improved growth and health followed.

This is exemplified in the extraordinary large-producing herd at Randleigh Farm, Lockport, New York, where these practices have been maintained through a number of generations of cattle.

CHAPTER XXIV.

RELATIVE COMPOSITION OF HAYS

AS EARLY as 1915 an attempt was made to determine the relationship between green grasses and minerals; especially the proteins and the minerals. At that time a herd placed on a ration containing nine percent minerals produced more milk than when fed a ration containing 5.5 percent minerals; this was the first concrete evidence that minerals are associated with the metabolism of milk.

Tops Analyze Highest

The protein and mineral content, we found, in many plants was in close relationship with the "green." We found further that there was a gradual increase of protein and mineral in every inch of the plant until the top, or rather the little leaf buds, were reached, and they contained as much as 32 percent protein and 15.8 percent minerals with the concentration of "green" in proportion. For practical purposes this indicated that the higher the plants were cut from the ground, the richer in protein, mineral and "green" the hay would be.

While some allowance must be made to the lower percentage of protein, which lowered the milk production of the herd, we found on the other hand, a hay containing eight percent mineral and 16 percent protein increased the milk production when equal amounts of "green" were present. However, the increased milk production was not due to the mineral alone. Since then many similar instances have been brought to our attention. There seems to be a quite definite relationship among minerals, protein and "green," which we now understand contain the enzymes and vitamin factors.

Effect of Fertilizers

We found in a number of analyses that as the plant grew to be over eight inches in height on poor soil, there was a decided reduction in protein and mineral and particularly a change in the carbohydrates, which apparently were changing into the indigestible celluloses. Several influences change the composition of the hay. We also found in this experimental work that fertilization was responsible for greater growth and greater mineral content in the plant not associated with a decided increase in the protein and carbohydrates of the plant. In some years, fertilization did definitely increase the percentage of mineral

in some instances and likewise the total volume of proteins and carbohydrates. Those constituents were quite variable from year to year, and no definite conclusions could be drawn, such as "fertilization of grasses would invariably increase the percentage of mineral and protein." Since the "green" of the plant decreased with age and the protein and carbohydrates remained almost constant, we found it difficult to find a time when plants could be gathered in order to show a standardized relationship. The variable conditions of moisture, sunlight, temperature, and chemical factors in the soil prevented a fair basis for comparison.

Short Pasture Grass Best

We did, however, discover that ordinary pasture grasses which reach a height of only three to six inches, such as timothy, bluegrass, redtop, and June grass, had a greater amount of "green", as well as protein, minerals, and carbohydrates, than did grasses reaching a height of 10 to 12 inches. We found too that by fertilization the same percentage of "green" was maintained in 12-inch plants from the five-inch to the nine-inch stage. (The determination of the percentage of "green" in these plants was done by making an alcoholic extract of the plant and then determining the "green" content.)

Although we had no direct method of making chemical determination, we found by clinical observations that the "green" of the grass was of a different character in spring than in fall. Apparently the spring "green" was of greater feeding value than the fall "green." After the grass is chilled and repeatedly clipped during the year, nutrients seem more indigestible and develop more toxins in the animal body, similar to the prussic acid formation in second-growth sorghum.

When drouth occurred, the average pasture, when fertilized before a rain, maintained its "green" for a longer period of time than when not fertilized, which is probably due to a deeper root system.

Juices of Hay

Although we had up to 1916 carried on a large amount of work to determine the value of the "green" in grass for feeding, we were not satisfied because of the incompleteness of our results. A laboratory test was planned. Two groups of young rats were fed on the same grain ration. One group was given water and the other received in addition to water, the juice of young rye, alfalfa and timothy sprigs, which were

about four inches in height and had been started in the spring in the greenhouse and later grown outdoors. The greater growth and increased reproduction of the rats that received the green juices, as compared with the rats in the other group, proved again the value of the "green" of the plant.

Mr. Barber, owner of Anna Dean Farm, then had a large number of green, early sprigs of alfalfa, timothy, and redtop analyzed; and we compared the results with the analyses of the matured plants. Even by our simple method of analysis at that time, we found the mineral in the sprigs extraordinarily high and in a colloidal form. The carbohydrates were in the form of dextrose, which is identical with blood sugars; and the proteins also were high in a comparatively easily assimilable form, but the fats were low. There was a large percentage of "green," or chlorophyll.

This result compared favorably with a second experiment which showed remarkable increase in the rate of growth of rats allowed feeds mixed with juices of some young green hays, as compared with the inferior growth of rats receiving juices of mature hays. The results were just as striking where heifers were fed young grass compared with another lot fed mature grasses.

Color Factors

Grass includes a number of particularly important factors, as chlorophyll, xanthophyl, carotin, minerals, salts, vitamins, pro-hormones and the enzymes, all of which combined with the common nutrients like protein, carbohydrates and fat, are essential for normal nutrition in the animal. However, each constituent has a more or less distinctive physiological effect; and the term "green" is used in this work to cover more than just chlorophyll, but rather it includes chlorophyll, xanthophyl, carotin and some physiological catalyzers. Also, "grass" is used for all forage crops fed to cattle and not limited to its botanical classifications.

The deep, dark-colored green of the alfalfa plant, we found from a clinical standpoint, did not show the desired red cell and hemoglobin increase as did the "green" of timothy hay, which was usually lighter in color. Dark green color then is apparently not a criterion to determine the value of grass from a nutritive standpoint. In fact, when the reddish "green" of redtop was fed, it seemed to show a greater hematological response than either the dark or the light "green." These

experiments were made largely on rats to which an extract of "green" was fed in combination with boiled milk. Much of this work was done under the direction of Dr. Ernest Scott (deceased), pathologist of Ohio State University.

How "Green" Content Varies

There was an apparent difference in the nutrition of the "green" grown on a gravelly limestone soil and that grown (as alfalfa) on dark muck soil. The first named was the better. A sandy loam gave still better results, but the most favorable results were obtained when this soil was fertilized.

The quality of the grass according to our observation is changed with weather conditions. A wet season produces a washy grass in which the color fades rapidly and usually does not feed well if made into hay. During drouth periods the grass naturally becomes brown; and as the time is prolonged it becomes more unpalatable. After a slight rain it "greens" rapidly, probably due to the accumulation of the minerals, particularly magnesium; if the drouth continues the grass becomes toxic, possibly due to the improper synthesis of the nutrients in the plant. Prussic acid may be a toxic factor.

Thus we find a marked change in nutrients from spring to fall. The grass becomes more unpalatable as the season advances and cows give less milk as a consequence, if the season heat is excluded. After a cool spell in the fall grass may even become so toxic that it causes a big shrinkage in milk production, which is frequently associated with a diarrhea or gastro-intestinal disturbance.

Alfalfa hay in spring does not develop the real bright green color, as in the third cutting in the fall, which often contains a high percentage of magnesium. This does not feed as well as the spring hay, even though it be of equal fineness and quality. Fall or second growth corn or sorghums are especially toxic, in fact, to such an extent that cattle sometimes die from eating such forage. Feeding germinated corn which contains large quantities of glucose is helpful if fed with fall-grown hay.

Pasturing short grass in spring gives the best feeding results, but hays mowed when 10 to 12 inches high, grown on fertilized soil, and used as a soiling crop seem to give about equally good results. These hays when dried apparently lose some of the growth-producing factors, and allow deficiencies to develop in the animals. It was during 1914

and 1915 that we tried to preserve these factors for winter use but were unsuccessful in our attempts. We tried curing the hays in various ways in the field, as windrowing, putting it in large hay cocks, and in small stacks, loose baling and curing in bales, all of which indicated too much loss of the "green." However, we did get an exceptionally good hay that was mowed and brought in green and dried under roofs on racks. Such a drier was later built near Hamilton, Ohio, in which the green grass was harvested and put in shelves under a shed where it was air dried. The labor and cost of this method was too great and the idea was abandoned.

CHAPTER XXV.

CORRECTION OF ABNORMAL CONDITIONS BY "GREEN"

WE HAD FOUND during 1912 in the Dimoc Brothers Holstein herd, East Claridon, Ohio, that cows fed large volumes of grain on test produced urine with a high sediment content. It appeared at first that the urine contained large quantities of albumen, but upon test it was found to be mostly sugar. We had at that time never heard of a physiologically diabetic cow. However, the urine revealed a high sugar content. The cows apparently appeared to be normal clinically, as well as could be determined at that time; but their milk did not develop nor nourish rats to healthy adulthood. Dr. Scott later called this a "pseudo-diabetic" condition; and we found that it could be changed by pasturing.

Sprouted Grain

This condition developed largely during the winter, but was also brought on in stable-fed cows during the summer, thus indicating again the lack of "green" in the feed rations. To produce a feed which would correct this condition during winter months became a problem. We thought at first it might be due largely to the low water content of the feed, and thus began to moisten hays. While this was helpful, still we found this was not as desirable as when sprouted grains were fed. With sprouted grains there is developed a large amount of glucose which prevents the development of what we now understand as "ketosis," or ketone bodies in blood of stabled cows. We also found that beets fed with sprouted grains were helpful in overcoming this condition.

In our research work on beets, we found that the rapid improvement of the cow was largely due to the soluble minerals of the beet and the watery nutrients of the living cell, particularly the alkaloid (betain), which stimulates the secretions of the reproductive organs and to a certain extent, the mammary glands and bone marrow. The studies of Best and his co-workers reveal that betain prevents the infiltration and deposition of excess fat in the liver of animals. We found that betain was largely a constituent of mangels and particularly red beets, but this again varies with the size of the beet, soil fertilization and climatic conditions.

In the light of our previous experiences in searching for a substitute for green grass, we also started to sprout corn and barley, which

we found would regulate the sugar content of the blood of the cow best, especially when fed together with beets. This sugar-regulating factor, named so by Dr. Scott, is now known as a "pro-insulin." At first it was thought to be a catalase enzyme. In the beginning of our work along this line, we found that during the sprouting of grains the diastasic enzymes changed starches into sugar, resulting in the formation of a residual gummy substance which became soluble after the complete conversion of the starches. We also found that by sprouting grains, we had overcome the unpalatable flavor of the milk which develops during January, February and March, or until green grass comes. It seemed that this was an oxidizing problem and was closely associated with the sugar-regulating factor and with vitamin C, which is now known chemically as ascorbic or cevitamic acid. Cows infected with mastitis were not considered in this experience because this usually influences the flavor of the milk.

Lack of vitamin C brings on a degeneration of cell walls, especially capillary cell walls, producing a sclerotic condition. Milk under such conditions is not properly synthesized, and any blood serum entering the milk canals and coming in contact with germs stimulates the growth of inflammatory germs, causing mastitis. These are held in subjection by the lactic acid germs of normal milk but still may be present in the udder where infection is present as a result of insanitary conditions. This so-called "half-synthesized" milk usually develops an unpleasant flavor and is the cause in many herds of a bad flavored milk in the spring.

While it had no relation to the function of ascorbic acid, we added a teaspoonful of hydrochloric acid to the feed of the cow. This we had previously found desirable when large quantities of grain were fed to increase the acidulation of the contents of the stomach, thus aiding the digestive powers. However, great care had to be taken to use some alkalizing agents later. While this method of feeding was the most desirable to overcome the abnormalities and deficiencies for winter feeding, still we found that young, green grass would completely replace this ration for summer feeding. Grass apparently contains these more digestible proteins, carbohydrates and minerals in combination with the "green," enzymes, vitamins, organic acids and plant hormones. Then we began to find these factors were greatly influenced by fertilizers.

Supplying Vitamins

Although some of the nutritional problems were vague to us from 1913 to 1916, we had nevertheless been feeding Scott's emulsion, or cod liver oil, which we now understand contain vitamins A and D; germinated grains and brewers' yeast, which we now understand contain B and G; and silage, germinated grains and beets, which supply vitamin C. We did not understand then the value of green alfalfa, which is unusually rich in vitamin G. These factors seemed to improve the calves produced by cows so fed. We also fed plenty of calcium, phosphorus, magnesium, iodine and iron, combined with sunlight. There was never a lack of the factor which we now call vitamin E, because the germ of wheat, as bran, supplying that essential was fed in considerable quantity. We fed these factors, not understanding the science definitely at the time, but we had experienced favorable results practically by doing so.

While we had decidedly improved the reproductive efficiency of these cows after a number of years by feeding a complex mineral ration associated with green grass and vitamins, there was still a deficiency which was observed clinically but which at the time could not be determined by any known test.

Suggestions were made by the veterinarians on the various farms with which we were cooperating that, as above stated, probably the quantity of feed consumed accounted for the deficiency; in other words, that the amount of feed overbalanced the digestive power. We had ample evidence, however, that certain cows could constantly consume large quantities without any harm, provided the feed was given in a highly saturated form. Through our observations and records we quite thoroughly understood that feeding wet feed with the undehydrated plant cells (especially when combined with beets and germinated grains) was far safer and gave better results than dry feed, because the nutrients were in a more digestible form, thereby causing an easier assimilation and utilization. All these factors and many additional ones are combined in fresh young grass which is available during the pasturing season. We finally discovered that our deficiency factor apparently was a red cell and hemoglobin problem, which the "green" of the plant supplied. As we now understand it, this is related to the chlorophyll factor found in the "green."

Heavy Pasture Yields

Even as far back as 1910, we had noticed the desirable effects of some fresh young hays for test cows on the Dimoc Farm, but we did not know then of the large amount of young hays that can be produced by frequent mowing of the grasses, which we later found to be a better system of feeding. Because the manure deposits on the pasture had to be frequently spread, we found that the mower was the best implement and incidentally cut the unpalatable grass around the deposits.

As an experiment these pastures were cut 11 times each year. A few plots have been made to yield 7000 pounds of dried grass, but 5000 pounds can be estimated as a safe crop with proper fertilization and frequent mowing. In numerous tests it has been found that more pounds of grass are actually grown each year by frequent mowing, due to the fact that as the grass matures it ripens and the roots become somewhat dormant if it is not mowed. By frequent cutting new sprouts are thrown out from the roots.

Soiling Methods

In 1922 we returned to the soiling method of feeding, which had been used in the past, to find what changes if any could be adopted to make this more practical. Edward A. Brown, then dairyman at the Toledo State Hospital, with Dr. O. O. Fordyce, superintendent, in cooperation with the Dairy Department at the Ohio State University, demonstrated the importance of feeding green feeds by stabling cows in box stalls and supplying them green soiling crops in the summer and sprouted grain in the winter. These grains contained some of the factors of "green" necessary to the cows in the winter. This research problem was carried on four years in a herd of 150 milking cows at the State Hospital.

A group of Holstein-Friesian cows fed in this manner produced an average of 18,500 pounds of milk and 447 pounds of butterfat, and every cow had a living calf. A second lot was given the ordinary dry-fed grain ration, consisting of corn, oats, bran, linseed meal and cottonseed meal, brown hay and corn silage, and was stabled in stanchions. These cows gave less than one-half as much milk as the first group, and 37 percent of them became sterile. During this time, we noticed that the "green" of young plants produced better results than the "green" from more mature plants when fed in the same amounts. John Allensworth, dairy manager of the Feeble-minded Institution, Orient, Ohio, corroborated these results.

We did not know much about vitamins, enzymes and plant hormones prior to 1922 and had no way to determine them, although there was plenty of evidence that some such factors which could not then be determined were present in plants. We now can reasonably suspect that there are still large numbers of undiscovered factors in feeds which can in many instances produce visible changes in the growing animal.

Hartman Farm Dairy Test

On the Hartman Farm Dairy, Columbus, Ohio, during 1928, where a herd of approximately 1000 cows was maintained, there developed an edematous condition among a large number of cows which resulted in low milk production and low reproduction. The cows had been fed a ration which consisted of silage and large quantities of cornmeal and cottonseed meal. It was known that cornmeal fed in large quantities was conducive to patchiness. This always developed quite rapidly, especially if the cornmeal was heated or old or somewhat moldy. Patchiness may also come about through heavy protein feeding, especially when the cow is sensitive to certain proteins. The summer months were dry that year; and there was little grass available. Consequently, the milking cows had little pasture and no green soiling crop that summer. As fall approached the barn was well-filled with brown hay. After a discussion with Edward Geyer, now of Grove City, Ohio, at that time herdsman, and Raymond Carr, who was manager, it was thought possibly a low protein ration might improve the cows at least temporarily; and an investigational program was planned.

A portion of the cows were fed cornstalks and brown timothy and bluegrass hay as roughages, and corn, oats and bran as the grain ration. This ration contained about $5\frac{1}{4}$ percent protein. These cows were compared with others fed a considerable quantity of green leafy alfalfa hay, some timothy hay, corn, oats, bran, cottonseed and linseed meal. This ration contained 14 percent protein. The patchiness somewhat disappeared in both groups of cattle and there was an improvement in milk production. In both rations the carbohydrates were rather low with little corn. The results in the beginning seemed to be quite favorable; but after nine months of feeding in the first mentioned group, the cows began to abort, and the calves that were born alive were scrawny and unthrifty. In the second case where the cows were fed the green alfalfa hay, the animals seemed to be thrifty and the calves were strong and vigorous. We therefore concluded that a five

percent protein was not sufficient, and apparently patchiness was not influenced as much by protein in the feed as by the kind of protein fed in relation to corn carbohydrates, which were not properly metabolized during plant growth. This was not associated with sufficient water to permit the kidneys to expel properly the waste products through the urine, which to a certain extent is the cause of some forms of patches or edemas. The principal point, we discovered, was the lack of "green" and minerals in the hay. Hay with "green" usually contains minerals in a more properly combined form, and the vitamins are in quantities that bring about improvement in the cows. The enzymes are probably of additional help when in combination with the proper kind of proteins, such as are found in good hays.

A blood test of the cows was made, which showed those fed $5\frac{1}{4}$ percent protein were markedly deficient in hemoglobin. According to Dr. Scott's experiment, this seemed to prove that the lack of chlorophyll in the plant and the low percentage of iron in the feed were other causes of this condition. The low calcium content of these cows' blood was also due to improper assimilation, but it also may have been due to the improper balance of other minerals in relation to calcium; for according to analysis, there was sufficient calcium in the feed. The clinical improvement of the cows in the second group we attributed to the "green" because, as we found later, it was probably due to the increased carotin or pro-vitamin A content of the hay. There also was undoubtedly a lack of vitamin D, for apparently the little calcium in the blood was not properly utilized by the body. The cows fed green alfalfa hay were constantly improving and had a low incident of infection. Their red corpuscles and hemoglobin were quite normal, which proved to us that while protein is one factor, chlorophyll, carotin, and minerals of green alfalfa hay are other essential factors.

Later a second investigation was inaugurated in which one group of cows was fed green alfalfa hay with a seven percent protein ration and another group, an 11 percent protein ration made up of brown hay and cornstalks, and without alfalfa.

The result of this test was that the cows on the seven percent protein ration with green alfalfa were in better condition than those on the 11 percent protein feed without alfalfa. This again demonstrated to us the superior importance of the "green" in the feed ration over the influence of the protein content of the feed. In fact, it proved that there is such a thing as a lacking factor in feed other than the problem of

protein, carbohydrates and fats. These last named were at the time recognized as being the only constituents that needed to be considered in any feed operation.

Beets—Necessary In the Dairy Ration

As early as 1908 in our work of feeding for high production, we had discovered that beets are an important part of the dairy ration. They have been fed on some prominent dairy farms for nearly 30 years. While corn silage has been considered equal to beets in feeding value on some average farms, we have not been able to get as satisfactory results with high-producing cows. We find that the acid cellulose of the corn silage can not replace the pentosans, pectin and hemi-cellulose of the beet.

Many high-producing cows do not seem to digest properly the raw acid cellulose. Therefore, in many instances we have resorted to cooking or heating cellulose with the starches in order to break them down. We have found this highly desirable for feeding for increased milk production. Beets are a more neutral feed. Pentosans, pectin, and hemi-cellulose in beets are naturally a neutral compound and form a gelatinous fecal matter other than cellulose.

The mineral content of beets depends somewhat upon the soil in which they are grown, but potassium seems to predominate in most cases. Therefore, beets fed with bran make a good combination. The phosphoric radical is supplied normally in bran by a compound known as phytin. This is broken down probably in digestion by an enzyme into inosite and phosphoric acid. The phosphoric acid is neutralized by combining with the mineral alkalies of the beet and is responsible for the normal elimination of calcium carbonate from the tissues which tend otherwise to collect and cause various symptoms of diseases.

Beets have some vitamins, particularly C; but if fed with dehydrated hays or other fresh green hays which have the vitamins in greater percentage, particularly A and G, the minerals of the beets are better metabolized. This is because the general function of the vitamins is to promote mineral metabolism. Beets grown on good soil contain 8 to 14 percent and average about 10 percent as compared with silage which has a mineral content ranging from $\frac{3}{4}$ to $1\frac{1}{2}$ percent. In beets there is also a desirable alkaloid known as betain, which has an effect upon the reproductive organs and mammary glands. Next to malt, we have found no feed that is so effective for increasing milk production

and regulating the reproductive glands as beets. However, the two fed in conjunction and supplemented with the high vitamin A and G hay, particularly dehydrated hay, and bran for the additional vitamin E is probably the best mixture known for high production, provided the other minerals, proteins, and carbohydrates are supplied.

Some acids interfere with the normal functioning of cellulose in the process of digestion. We have found that with high starch rations cellulose becomes an important factor in feeding cows for high milk production. We do not want to leave the impression that silage is not a good feed for ordinary producing cows, but for maximum production we have always found it necessary to replace silage with beets or some other non-acid cellulose like that of beet-pulp. It must be said, though, that cows tending toward alkalosis can handle the acid cellulose better than beets, but this is rare.

Beets are most valuable for fall and winter feeding. They become less effective for milk production as spring approaches. This depends to a certain degree on how they were stored. There is probably no better way to store beets than in pits located on high ground. The beets are laid in piles at the proper angle on two feet of straw. They are then covered with two feet of straw and then the straw is covered with earth. In real cold weather, the earth should be covered with manure, preferably horse manure because of the heat of fermentation. However, for early winter feeding and even up to the last of February, we have found it best to store them in a one-story, board structure or an enclosed shed in which the floor is covered with baled straw and the inside of the building lined with baled straw. Compartments are made about eight feet wide and six feet high and as long as necessary. When filled, the entire top is covered with loose straw. The front of the compartment must be well protected at the opening through which the beets are removed. Unless properly protected cellars are not so good because mold starts to grow at the crown of the beet and it becomes dangerous feed, especially late in the spring. Some people have suffered great loss by feeding moldy beets because of this poisonous character. Beets ought to be consumed and not carried over later than the middle of March.

Beets should be grown in well-fertilized ground that has been manured at least a year previous to planting. Loam soil has produced the best beets as a rule but a clay loamy soil can grow beets successfully. A slight amount of sand and gravel mixed throughout the soil is bene-

ficial. Depending upon the nature of the soil, from 400 to 1,000 pounds of complete fertilizer is used per acre. The crop yields abundantly if well fertilized. From 16 to 24 tons per acre is no uncommon yield.

There are two ways of planting beets. One is to drill the seed in rows, allowing the plants to grow and then blocking out the superfluous crop with a hoe. This entails considerable labor, but if properly done, produces a large yield per acre. A more convenient way is to sow the seed in hotbeds. Prepare the ground upon which they are to be planted early in the spring and keep the ground cultivated in order to keep down the weeds until planting time. The plants are removed from hotbeds and planted about the middle of June with a cabbage planter. Except for a little cultivation, there is no other labor necessary. The beets make their greatest growth in the fall after the rains. They require a large amount of moisture to develop.

Beets have been grown on Randleigh Farm for a long time. They are always fed in conjunction with some germinated grain or silage. The beets are sliced for feeding which furnishes an abundance of good, succulent, fresh feed. In nearly every instance, the cows relish the feed.

Beet pulp, while very good, can not be substituted for beets. Beet pulp can only be fed to a moderate degree, in comparison with the amounts of beets that can be fed. Of course, beet pulp should be fed after it has soaked. Even beets should be considered supplementary to a good hay and grain ration. At Randleigh Farm beets are considered an essential part of the feed ration, and here is one factor that is helpful to producing the high records made on this farm. It is a decidedly desirable contributing factor to the splendid reproduction.

The cost of raising beets depends upon the yield per acre. The cost of silage is less than that of beets. From the standpoint of feeding, beets bring much better results and are more economical.

CHAPTER XXVI.

MANAGEMENT OF PASTURES

KNOWING the high feeding value of pasture, Hugh Bonnell, Cranberry Run Farm, Youngstown, Ohio, began in 1922 his pasture experiments after he had discovered the great importance of "green" as a feed constituent necessary for the prevention of many abnormalities produced in cows forced to higher production. Mr. Bonnell had experienced many difficulties with his former feeding operations, and thus his primary object was to increase the "corrective" factors in his feeds. Feeding had to be an economical system on his farm and one which would develop a milk of high nutritional value.

A New Pasture Development

This was the beginning of a new pasture development. Without cultivating any other crop, his income of recent years has netted him a greater profit by this system of farming than he had received from any other program in recent years on a like acreage. During the summer he maintains 150 cows and heifers on 80 acres of pasture, a small part being woodland. This system is naturally not practical everywhere, but on most large dairy farms it can be easily adapted to reduce the labor and expense and produce a milk which has a special nutritional value.

It has been a fact in the past, especially on average land in north-eastern Ohio and in northwestern Pennsylvania and western New York, that it costs more to raise grain than to buy it over a period of years. This is likewise true with ordinary hay, but not with high quality hay. Forages, therefore, can be produced more cheaply in the immediate vicinity, and pastures necessarily should be developed on the farm where the cows are kept.

Previous to the beginning of his pasture research work, Mr. Bonnell was making phenomenal records on a large number of cows, by feeding them heavy grain rations rich in proteins and in starches and sugars. He had 18, all of which were high producers, on Register of Merit test. We observed at the time that some of these cows, especially those tested consecutively the second and third years, had developed certain abnormalities which we thought were probably due to improper metabolism of feeds. Later some of these nutritional problems became more lucid to us, and we conceived the idea that nature could more properly

balance and supply the "green" and the other nutrients mentioned above in young grass.

Seeding A Pasture

H. A. Lehman, former county agent in Mahoning County, Ohio, in cooperation with Mr. Bonnell and the Dairy Department, of Ohio State University, began in 1919 a research problem on a three-acre patch of coal bank land on Mr. Bonnell's farm. This soil produced little more than straggling weeds because of lack of humus. After liming to reduce the acidity to a pH 6.7 average test, the soil was heavily manured for two years with cow manure, phosphates and potash. A 100-pound application of ammonium sulphate and nitrate of soda was made early in the spring of the second year, and a seeding mixture which consisted largely of white clover, bluegrass, timothy, red clover, redtop and orchard grass was sown. This mixture was used to insure grass most of the year, taking into consideration drouth, etc.; but it was soon found that the mineral content of the soil, the season, and the moisture largely regulated the growth and kind of grass, and that it made little difference what mixture was sown.

Five weeks after the first application, another 100 pounds of nitrate of soda which contained some iodine was added, and at the end of the season the predominating grasses were bluegrass and a little white clover with some timothy. These nitrogen fertilizers invariably increased the protein and the minerals of the grass.

The Hohenheim System

My visit to the Hohenheim system of pasturing in Germany in 1906 had impressed me with the importance of giving pastures a rest, by dividing them into three plots, and allowing the cattle to browse for only ten days on each plot. This is always conducive to the development of better and more digestible nutrients in the grass. While at first we found this system somewhat impractical, we succeeded in modifying it so that now it has become quite successful.

In order to have pastures furnish the best nutrients for cows, it becomes necessary to develop a good root system, for the roots must absorb and manufacture the nutrients for leaf development. Also, there should be sufficient leaf surface exposed to the sunlight. This helps to synthesize the plant foods in the soil into roots, and then these are transported to the leaves. Therefore, the more sunlight on a large leaf surface, the more roots and blades of grass there will be with

more abundant and better nutrients. By having cattle constantly grazing in one field, the diminished leaf surface results in a poor root system, which in turn develops unbalanced nutrients, and gradually the grass becomes tough and bitter as the season advances. By fall, even with plenty of moisture, the vitamins, especially A, are low; and the cows do not get the protection and nourishment in general they ought to have before winter.

Constant direct sunlight is not always essential, for it has been found that fogs irradiated by sunlight carry an amount of light that will furnish grass with sufficient irradiation. Time, water and warmth are important for grass to grow, and to produce the properly balanced nutrients. Therefore over half to two-thirds of the season the grass should be unmolested and allowed to grow at intervals of two weeks. It is preferable to have the pasture fenced into three lots and allow cows to graze but ten days in a lot, after which it should be clipped and allowed to grow 20 days. By this method a smaller area of land furnishes more and better pasture than the same acreage in larger pastures.

Pasturing large areas of land constantly should be practiced only on waste, cheap or untillable soil. On good land such a practice is not economical, for cows graze only where the grass is short and palatable, which area becomes overgrazed while the balance of the land is wasted. This system also furnishes more abundant and better grass in times of drouth.

Irrigating Pastures

If the plot can be irrigated, this is extremely helpful in maintaining good rich grass and can be done by a rather inexpensive system. A 2.5 to 4-inch tube of ducking (ooze hose) laid across the field through which water can be pumped is sometimes used. A gas engine and a pump, provided ample water supply is available, makes an effective scheme for irrigating pastures during extreme drouth. The mowings after each change of pasture retain the greenness of grass to a great extent. The clippings are allowed to remain on the pasture, thereby preventing rapid evaporation of water in the top soil. It is during extreme drouth that deep-rooted plants like alfalfa and sweet clover maintain their "green" better than some of the other plants do.

Our earliest attempt at irrigating pastures was at Anna Dean Farm, Barberton, Ohio, where the manure of the large dairy barn was stored

in concrete pits below the stable. With the manure (both solid and liquid) were mixed such fertilizing materials as nitrate of soda, ammonium sulphate and gypsum. All the mass was liquefied and then pumped by a 60 H. P. motor to a high point in the pasture, from which place it flowed by gravity through tile drains across the field. In this gravel soil the system worked satisfactorily.

Dan J. Schaaf, Columbus, Ohio, had a similar system of sub-irrigation in his pasture, using only the liquid portion of the excrement. The manure is hauled to fields while the liquid part, mixed with lime, nitrate of soda and ammonium sulphate, is spread on pasture soils by sub-irrigation. Here again the plan has worked well.

On the Randleigh Farm a similar program was started in 1932. A ramp was built in connection with the milking parlor and the cows walk up it to be milked, going over a grating above a gutter. The gutter was flushed out after each milking and the sewage went into a septic tank under the barn. Later a dousing plant was built, out of which the liquid flowed into a tile distributing system with the tile about eight inches under the grass of the pasture field. This tank discharged the sewage into the tile and it leaked out around the joints.

This did not work well because of the clay soil, while on other farms a gravelly soil prevailed. The sewage could not be distributed for more than four feet. A subsoiling machine was then used to make an opening through which sewage might pass, but this was soon closed up by the material. Mr. Kenan then put these tile into small pockets acting as traps and distributed the liquid material from these points, but as yet the results have not been entirely satisfactory. It does dispose of the sewage, but the grass is not palatable to the cows. The best procedure to fertilize pasture lands still appears to be through frequent small applications of fertilizers. It takes several years to develop a good rooted mat of pastured grass before cows can graze on it in early spring and in rainy seasons without breaking through the sod.

Clipping Pastures

Mowing of pastures was first developed on the Bonnell Farm after repeated tests were made on the grasses grown on these pastures. We found that young short grass was much richer in minerals and high nutritional constituents than the tall mature grass was. Apparently there is a need to digest some cellulose although the amount and manner

of digestion are not known. In herds where all grains are fed we find the cows do not produce as well as when some of this chemically loosely bound cellulose is fed, taking minerals and vitamins into consideration. We also found that grasses grown on certain spots on the field were not grazed because the grass was unpalatable, probably due to urea compounds from excretions of the cow. By repeated cutting of the tall grass we seem to have reduced the unpalatability in the young sprigs, especially after rains. Small pastures, frequently clipped, have fewer of these unpalatable areas in comparison with large unclipped pastures. Likewise the small pastures contained a much more nutritious grass than the large pasture plots.

CHAPTER XXVII.

FERTILIZING PASTURES

IN THE BEGINNING of our fertilization work for the purpose of developing "green," we found many conflicting results, which we now understand was due to many varying factors. We did know that in 1911 the hay that gave us the best results and kept the cows in best condition for producing milk was obtained in northern Ohio in the vicinity of Gypsum. This hay had the most "green". Since that time the hays for some reason have become somewhat inferior, probably due to the reduced fertility of the soil. Our analysis of the soil on which the hay grew in 1911 indicated not only a high calcium sulphate content but also a fairly high magnesium content, and too it was rich in organic matter. Fertilization with phosphate in addition to calcium and magnesium in other areas also produced considerable "green". This of course led us to segregate these two fertilizing constituents by adding one to the soil directly while fertilizing, the rest by application to the leaves and stems. This seemed to increase the percentage of "green" in the grass and at the same time apparently increase the iron content as well.

Iron and "Green" Relationship

This led us to another discovery as to the relation of "green" and iron in grass, which seems to increase the hemoglobin in the blood of the cow. In several tests this factor seemed to have been transferred through the milk, which in turn increased the hemoglobin in the blood of the rats used in experimental investigation. This may likewise occur when such milk is consumed by the human being.

This particular investigational work on pasturing was later carried on at the farm of Mrs. George Eustis, Madisonville, Ohio. Dr. C. A. Doan, Medical and Surgical Research Department, Ohio State University, determined the results of this system of feeding.

Care must be taken not to mix iron compounds with phosphates for that renders them both insoluble and neither the iron nor the phosphates can then be taken up by the plant. It seems best to put phosphates on the soil in winter when they can be partly synthesized in the early grass. Barring natural deficiencies the amount of phosphate needed depends upon the clay or colloid content of the soil.

This was well worked out by George Scarseth, of the Soils Department, of the Ohio State University. He discovered that a ton of superphosphate would be necessary on some heavy clay soils to produce the same effect in plant growth as 300 pounds of superphosphate on light sandy soils. This fact was well illustrated on the Randleigh Farm. We found a part of the farm, especially where the pastures were located, did not respond at first to fertilization. There is now no question in our minds but what this was due primarily to the low percentage of available phosphates in the heavy clay soil. Pastures responded well on the loam and sandy soil on this farm. We failed to find an economical source of organic phosphate.

Where the land is properly limed, we find that ammonium sulphate also produced considerable "green". Sodium nitrate gave us some "green" but not as much as a combination of sodium nitrate and ammonium sulphate. One of the best fertilizers was magnesium sulphate in combination with ammonium sulphate and nitrate of soda, on a well-limed soil containing considerable organic material. In nearly all cases it was quite necessary to get the proper combination of all factors, depending upon the nature of the plant. For alfalfa and timothy, redtop and white clover, a fairly well-limed soil with a heavy phosphate and potassium fertilizer supplemented with ammonium sulphate and nitrate of soda and manganese sulphate gave us the best results for "green".

On the B. G. Dawes Farm, at Newark, Ohio, hay was procured in 1922 from an irrigated district of Arizona. Some of this western alfalfa hay that was early cut had an extraordinarily large amount of "green" in it, but apparently slight changes in moisture conditions and maturity made a decidedly inferior hay. The only opportunity we had to find out the mineral contents of the soil was to get a sample from a small area which again showed us a high calcium and magnesium content in a gravelly, loose soil. We had, up to this time, not drawn any conclusions as to what particular mineral produced the greatest amount of "green" except that possibly the iron catalytic agents like manganese had to be combined with general fertilization. On the other hand, fertilization of grasses gave us a great many results contrary to what we had anticipated as, for illustration, the mixture of iron and phosphates applied to an alkaline soil, actually gave us a lower "green" content than without them.

Iodine Fertilization

While such fertilizers as phosphorus and potash are constantly applied during the winter with manure, more nitrogen fertilizers are of additional importance, as for instance, ammonium sulphate with iron manganese compounds applied in the spring. Repeated small applications of nitrate of soda were made during the summer season. Special attention was paid to the fact that the nitrate of soda should be combined with a little iodine, provided the manures have not been reinforced with this constituent, because we have found iodine in small quantities to be one of the most important mineral elements. Iodine seemed to increase the activity of the thyroid, which was associated with better reproduction and in many cases apparently increased the fat content in the milk. Wherever iodine was fed in the stables a tank was provided for collecting all the liquid manure which was to be put upon the pastures to stimulate early plant growth.

Iodine absorption of the plant and metabolism in the cows were well demonstrated by experimental work at W. W. Kincaid's Farm, Niagara Falls, New York, in cooperation with Dr. George Curtis of the Medical and Surgical Research Department, Ohio State University. It was found that when $1\frac{1}{2}$ grains of iodine were fed to a cow daily there was an increase in the iodine content of the milk from four gamma to 168 gamma per 100 cc. of milk, while 50 gamma per 100 cc. of blood is thought to be the lower limit necessary to prevent development of goiter in the human family. Thus one pint of milk from cows fed 1.5 grains of iodine daily would prevent goiter development in human beings.

Iron and Manganese

It has been long known that under certain conditions some plants absorb small quantities of mineral fertilizers through the leaves and surface roots. It was our privilege to put these scientific facts into practical operation. While the rate of absorption varies, sufficient amounts of manganese and iron were introduced into the plant to influence somewhat the metabolism of the cow. The iron mixture which was blown or sprayed on the grass consists of 25 pounds of manganese sulphate, $5\frac{1}{2}$ pounds of iron sulphate, and 3 pounds of copper sulphate, with $1\frac{1}{2}$ pounds of potassium iodide. (Much better results can be obtained by using iron ammonium citrate.) This constituted a 35-pound application of fertilizer per acre for grass.

Lime and Acidity

When growing pastures, we aimed to develop a mat with straw and manure which kept the iron mixture from intimate contact with the soil. As time went on and the grasses were frequently cut and manured, a mat of humus with fine rootlets developed. This also naturally held moisture and at the same time allowed the cattle to graze early in the spring when it was wet, without breaking through the sod. The organic decomposition in the humus maintains a slightly acid condition which is so essential for a good flavored grass, but a soil with a pH value of 4.5 or less makes an unsavory grass. This is particularly true where excessive amounts of ammonium sulphate are used.

Therefore, the intricate problem had arisen of keeping clovers growing on a highly iodinated soil with enough acid to make the phosphorus and iron constantly available to the plant. The absorption of calcium ions into the plant for good flavored grass was probably best maintained by the use of calcium sulphate. Yet even with continued use of calcium sulphate, there came a time when the soil became so acid that an application of lime was necessary to bring up the hydrogen ion content in the soil for good flavored grass. The top soil ranged from pH 6 to 6.5, while if possible, the higher pH base soil should have been maintained with limestone fertilization. In fact, patches in the pasture ranging from pH 5.5 to 6 were not desirable. However, it had to be remembered that this checked the growth of clover and leguminous plants unless calcium sulphate had been used, which was obtained in large quantities by the use of superphosphate. In some instances we had provided for small plots of pasture in order to have a high acid pasture grass in one part of the field and a low acid pasture grass in the other part of the field, as a variety for cattle. If the grasses were young, it was not uncommon to see the cows browsing upon the high acid grass, even though the amount of "green" was smaller and oxidizable materials were higher.

Ammonium Sulphate

Heavier applications of ammonium sulphate were used wherever necessary since the ammonium sulphate became an important factor in keeping the soil in an acid balance. It was rather dangerous to bring the alkalinity of the soil to the neutral point where the iron and phosphorus became unavailable to the plants.

Too much ammonium sulphate made the grass unpalatable. This had been well proved on the pasture of the Dan Schaaf Farm, Columbus, Ohio, where the cows refused to eat the grass. In this case a 700-pound application was made for three years. Therefore, in preparing the pasture, be it a stony limestone, granite or mountainside pasture, such as found on Campbell's Clearview Farm, Butler, Pa., or clay soils or sandy loam soils, it was first necessary to apply considerable limestone, most of which was not finer than one-fourth inch mesh. This was done by drilling the limestone in the grass whenever it was convenient. On the level soil that had been cropped, it was worked in after plowing. However, plowing was not necessary and on many of the soils which were extremely rough, it was impractical. Upon these pastures we began by applying manure after liming, preferably manure made from cut straw or peat moss. To every load of manure we added 40 pounds of 20-percent superphosphate and 15 pounds of potash. This application was made early in the fall and during the winter at the rate of about six loads to the acre. More or less was applied depending on the amount of straw in the manure.

Basic Slag

On a number of pastures, we applied phosphatic slag in quantities of three tons to the acre with the expectation of increasing the "green" in the grass. On C. F. Michael's fields, Bucyrus, Ohio, we found that the "green" was increased by slag. In fact, a larger amount of "green" was obtained than where limestone was used. Grinding the slag to a fine powder was necessary, however.

An early spring application of liquid manures followed by dusting of ammonium sulphate, manganese and iron, was found to be extremely desirable, especially after the grass had started. A large septic tank with a good cover, such as Mr. Michael had built, was a fine storage space for the liquid manure that accumulated during the winter. This tank is 20 feet long, 10 feet wide, and 8 feet deep. The water used for scrubbing the stables once weekly also flowed into this tank. A little copper sulphate was sprinkled into the gutter to prevent infection; likewise a little iron sulphate was sprinkled into the manger. Calcium sulphate or gypsum was used to cover the floors, making them white and attractive. Lime was used in limited quantities, but care was taken not to get too much lime into the pit, as this makes the iron less soluble.

In some instances we also used a magnesium silicate for pasture fertilization. We realized that there was an abundance of magnesia,

especially if the proper kind of limestone was used. There was apparently, however, an improvement in these grasses, especially in timothy, on soils where the readily available magnesium silicates were used.

Stages of Growth

However, grasses develop different nutritional ratios at different stages of growth. We have discovered that the practical stage in grass, particularly bluegrass and white clover, occurs when it is from four to six inches high. With timothy and common red clover, however, it may be four to eight inches in height.

While the pasture problem is an old one, the system that has been introduced on the Cranberry Run Farm to develop pasture grass with a high mineral, chlorophyll and vitamin content, endeavoring to produce healthier cows, more milk and a higher nutrition in the milk, was a new and original practice. The development of this work has taken a great many years of study and a great many tests were necessary to check results. While Mr. Bonnell started this work on pastures, much original work has been added by Wm. R. Kenan, Jr., Randleigh Farm, Lockport, N. Y.; J. S. Campbell, Clearview Farm, Butler, Pa., C. F. Michael, Chuck Walt Farm, Bucyrus, Ohio, and W. W. Kincaid, Niagara Falls, N. Y.

There constantly arises the question of whether it is economical to go on with this work, which to the average man's mind is a rather hazardous expense. Yet we find a great many men who are tilling and fertilizing soil for corn, cultivating, cutting, harvesting and ensiling this crop at a much larger expense, at the same time losing approximately 30 percent of the quantity of feed in preservation, and making a feed that contains less than one-half of one percent mineral with little or no vitamin C. In grass properly taken care of the mineral constituents range from eight to ten percent associated with a large percentage of food nutrients.

Economy of Pastures

For many years Mr. Bonnell has turned his herd out on a limited area of his pastures between the first of March and the first of April. This young grass starts a cow early in the year on a heavy production and better milk. The test cows are fed grains in connection with the pasture as the high water content of the grasses does not furnish a sufficient amount of concentration for extreme high production. No grain is fed to the rest of the milking herd from early spring until

late fall, approximately October, the pastures furnishing all the nutrients for the cows. This procedure may be followed even as far north as the Lake regions, where Mr. Bonnell's farm is located. In fact, it was the first week in November in 1935 before the cows were taken off the pasture. However, some grain or hay feeds must be fed during the month when the grasses are frosted, as the character changes in the latter part of the summer, and when grasses are once subjected to moderately low temperatures they become less digestible. This condition can be improved (if grass is not too short) by cutting or pasturing along with fertilization. Naturally this depends upon the year and the weather conditions, but a great saving has been effected. For the last five years summer feed costs for his herd of 150 head have averaged \$531 per month less than during the winter months.

In combination with these pastures, Mr. Bonnell is fringing his fences with shrubs and perennials, particularly elderberries, black haw, foxglove, etc. It has been difficult to maintain a proper growth of elderberries as the cows are so fond of them. They seem to have therapeutic value. He was obliged to plant a large number of shoots one year and fence them in so as to allow them to get a good start. From all observations, there seems to be a favorable effect from the alkaloids of these plants, especially early in the spring. The black haw seems to have a desirable effect upon the membrane of the uterus of the cow; and a small amount of foxglove, which furnishes the basis of the alkaloid digitalis, seems to stimulate the heart and other muscles.

This was one of the earlier places where we fertilized pastures with 600 pounds of magnesium sulphate (Epsom salts), which increased the magnesium content of the grass nearly 100 percent. This had a desirable effect upon lactation of the cows eating this grass.

To summarize: There are many vitamins, many pigments, many minerals, many hormones, many enzymes (and many radiations), besides the necessary proteins, carbohydrates and fats, to consider when formulating an adequate ration for production, reproduction or therapeutics.

C. R. Houston, of Franchester Farm, owned by C. C. Bolton, South Euclid, Ohio, has been raying calves for a number of years. He reports favorable results observed from a clinical standpoint, which conforms with the work done on Randleigh Farm. Pasture radiation is a factor that must be considered in combination with the feeding of "green," especially in case of growing calves.

CHAPTER XXVIII.

NUTRITIONAL VALUE OF THE "GREEN" OF GRASS AND HAYS

THERE were many hemoglobin and red cell tests made up to 1926 to determine the effects of "green" in grass and hay.

The results invariably showed a fair relationship between the amount of "green" and increased reproduction and likewise a more nutritious milk. Yet, more evidence was necessary to understand the specific physiological effects which were improved. Hence, according to Dr. Ernest Scott's work, the "green" of the plant was divided into chlorophyll and carotin. The xanthophyl, which seems to be a breeding factor, was separated from the "green" later.

Drs. Scott and Lowell Erf set up a series of tests and used as a base the determination of red cells and hemoglobin (as well as the weight of rats) given milk from cows fed with various feeds. The conclusions of this work led us to realize the importance of "green" more than ever. The hemoglobin and the red cells and the weight of the rat were increased by increasing the "green" or the pro-constituents of "green." These are found in germinated grains. The final conclusions from this experiment were read before the *American Association of Medical Milk Commissions* and the *Certified Milk Producers' Association of America* at the annual meeting at Detroit, June, 1930, and were published in 1930.

Later the work done by these same men at White Cross Hospital, Columbus, Ohio, on carotin (which had been discovered by Mellanby of England, who found it to be a highly important part of the "green") showed that carotin alone does not produce the favorable protective factor that develops when it is fed as "green." Evidently it is necessary to have carotin combined with other constituents of the "green" to produce the most favorable results. Xanthophyl, we began to realize, seemed to be a factor in reproduction, for pure chlorophyll and pure carotin fed in combination with a ration containing no "green" showed that reproduction was not enhanced.

Although these tests gave a somewhat positive assurance, a second test was inaugurated in 1931, the work of which was published in the *Veterinarian Alumni Quarterly* by Scott, Erf and Delor, Department of Pathology, Ohio State University, on the influence of the feed of the cow upon the nutritional value of milk, which we hereby quote in its entirety:

Experiments of Scott, Erf and Delor

"Aberdalden in 1900 demonstrated for the first time that laboratory animals fed a diet of milk only develop unmistakable evidences of anemia. Bunge, a year later, showed that milk was notably low in iron content. Consideration of previous observations of anemia, and of the fact that hemoglobin contains iron, has led to repeated attempts to demonstrate the therapeutic value of iron in anemias of various etiology. The results, however, have never been completely satisfactory. Following these first attempts for a solution of the anemia produced experimentally with a sole milk diet, there was nothing further of interest until the problem was re-opened by Hart and his co-workers in 1925 at the University of Wisconsin. They later reported remission of milk anemia in rats by the addition of iron and copper to the diet, though iron alone was ineffective.

"The therapeutic value of iron in the treatment of nutritional anemia has been a matter of some controversy. Beard and Myers, after a series of experiments with metallic iron, electrolytic iron, and H_2S iron, found that .25 mg. of Fe daily was the necessary supplement to a whole raw milk diet to produce hemoglobin recovery in six weeks and red corpuscle recovery in four weeks. By increasing the dosage of the iron up to 2 mg., the time for recovery was reduced to 1.8 weeks. This is an agreement with the results obtained by Mitchell and Schmidt, Drabkin and Waggoner, and Keil and Nelson. Hart and his associates, Lewis and Krauss do not agree that pure iron will cure nutritional anemia. The extensive work of Beard in obtaining pure iron would seem to indicate that unless contamination occurred before consumption, any effect received therefrom must have been contamination, or else impurities of copper were present in the iron salts used. Steenbock found that the smallest amount of copper necessary was .0025 mg. daily. He says that this must have been present as a contamination in Beard's and Myer's materials.

"Myers and Beard maintain that they found .01 mg. of copper and .5 mg. of iron not sufficient to reduce the time of recovery from nutritional anemia to less than six weeks, which is the time for recovery with iron alone. When, however, the copper was added in greater amounts, .025 mg. and upward, the period of recovery was cut down to two or three weeks. Other inorganic substances found that would also catalyze erythropoiesis were daily doses of .05 mg. Ni, .4 mg. Fe, .01 mg. As, .1 mg. Zn (.5 mg. Zn depressed hemopoiesis), .5 mg. Hg.,

while cobalt, magnesium and aluminum were ineffective. Myers in commenting on the presence of sufficient copper in the milk itself says, 'It does not seem to us that when essentially the same effects were obtained with a number of other inorganic supplements in addition to copper, their action can not be explained so simply.'

"Supplee, Dow, Flanigan and Kahlengerg found that milk takes up iron from the container in the process of drying. The milk used by Beard and Myers in their experiments was whole raw milk obtained with special precautions against iron or copper contamination. Beard says that in the milk they were feeding, 75 cc. contained .35 mg. copper. The animals used were weaned from mothers receiving lettuce, which is rich in iron and copper, and yet these young rats developed nutritional anemia on a whole milk diet, showing that there was no storage of iron or copper in their bodies. Hill says that nutritional anemia is a deficiency disease, depending upon a lack of iron and possibly a pigment in the diet.

"Agents other than inorganic elements have been found which favorably influence erythropoiesis. Furniss found that ultraviolet light stimulated hemopoietic function. Osato and Tanaka, using a General Electric Sunlight lamp, found the same effects as Furniss. It is evident then that the irradiation of experimental animals on the whole raw milk diet with the subsequent prevention of nutritional anemia would indicate that vitamin D was concerned, while Moore states that vitamin D is essential for the action of carotin in producing normal rat growth on a milk diet. It is thus seen that the influence of the addition of Fe and Cu to the diet of the anemic rat is not on an entirely established basis, that different experimenters have obtained varying results, that essentially the same effects may be obtained with a number of other inorganic supplements, that the ultraviolet light, the carbon mercury lamp, and other irradiations have all accomplished a definite erythropoiesis.

"It is generally granted that the iron and other inorganic elements in milk can not be increased by increasing their amount in the feed of the cow. This is not true, however, for many other substances, it having been recently proved that the vitamin content of milk is directly and entirely dependent upon the quality of the food consumed.

"One of the most recent and striking proofs of this is the work of Thomas and MacLeod and of Krauss and Bethke, who have proved that the anti-rachitic vitamin D is greatly increased in the milk of cows fed

upon irradiated yeast or irradiated ergosterol. Thomas and MacLeod find that vitamin D can be increased in the milk as much as 16 times in this manner.

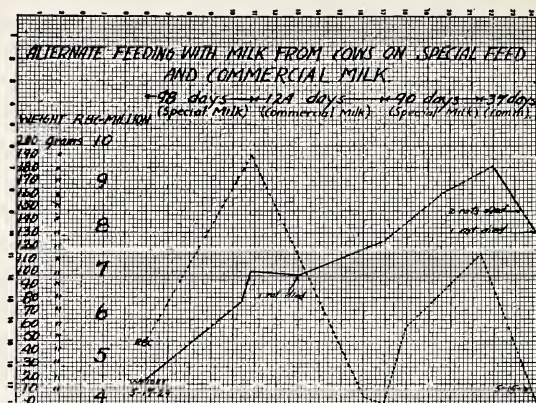


FIGURE 1

"Hess and his co-workers have utilized this fact clinically and report many advantages in both the prevention and the treatment of rachitis by the feeding of anti-rachitic cow's milk, stating that when rachitic infants were fed upon such milk, definite calcification was brought about within 30 days.

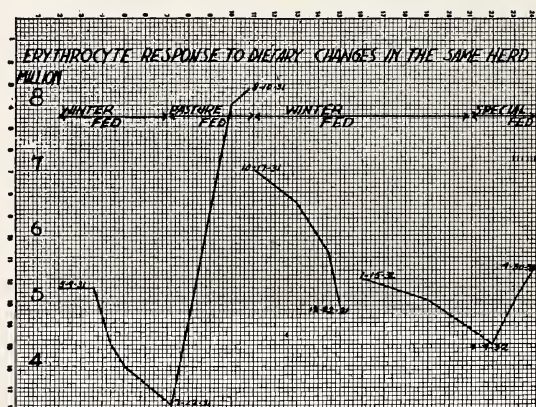


FIGURE 2

“Roessler in experimenting along similar lines found that the milk of cows on a green fodder diet had the same effect as ergosterol, but that winter milk did not possess this property.

“Hunt and Krauss have proved that the milk from cows on green pasture has a higher vitamin G content than cows on dry feed, and that

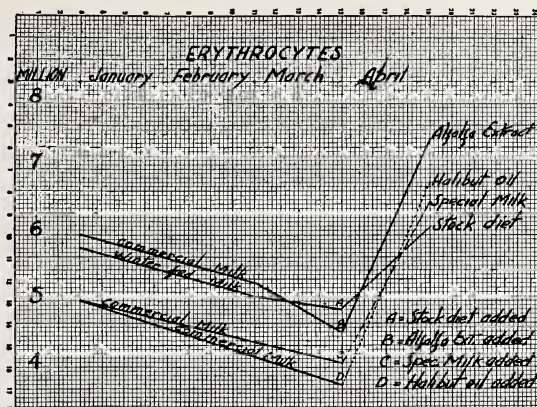


FIGURE 3

cows on pasture during a vigorous plant growth produce milk with higher vitamin G content than those on pasture that is over-mature. These authors also state that vitamin B is influenced in the same manner but to a less degree. Ernst states that both quality and quantity of

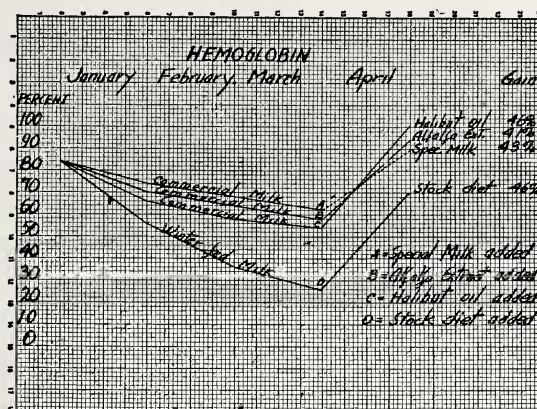


FIGURE 4

milk are dependent upon the quality of the cow's feed and also that the texture and quality of butter are determined by the diet of the animal. Brown and Sutton have proved that the administration of Menhaden (fish) oil to producing cows not only lowers production, but also the percentage of butterfat and the total amount of butterfat.

"Daniels found that vitamins are present in the milk only in the proportions existing in the diet of the animals producing it.

"Lachet indicates the growing belief among investigators that carotin, the yellow coloring material of plants, is definitely correlated with the physiological activity of the fat soluble vitamin A. Burgi, from an extensive experimental series, states that chlorophyll is *the* or at least one of the growth factors and either is vitamin A or absorbs it. Zih in feeding rabbits observed an erythropenic effect, not controlled by vitamin B or C, when dry or chlorophyll-free food was used. The addition of chemically pure chlorophyll or of green food to the diet caused a rapid return to a normal red blood count. He postulates that the hemopoietic effect of chlorophyll is due to its reduction products which are thought to be related to those of hemoglobin and to have the same irritative action on the blood-forming elements of the bone marrow. Hart states that we now know, or think we know, that carotin is the precursor of vitamin A and that vitamin A is more abundant in the milk of pasture-fed cows than those stall-fed.

"Olcott and McCann have recently added the necessary proof of this statement by combining the liver tissue of a rat suffering from severe vitamin A deficiency with carotin and allowing them to incubate over night. When upon examination they were able to demonstrate a spectroscopic band for vitamin A which was previously absent in both the liver and the carotin, these workers further proved that by heating the liver tissues before the addition of the carotin, no vitamin A band appeared. This is of interest in the present connection because of the fact that carotin in association with chlorophyll is the pigment which gives the characteristic green color to the grass and to the leaves of trees and plants. Chemists inform us that the chlorophyll of the green grass and vegetables is almost identical in chemical composition with the hemoglobin of the blood, apparently performing much the same function in the plant as does the hemoglobin in the animal body, the only essential difference being that the structural units of chlorophyll are linked together by magnesium, while those of hemoglobin are linked by iron. As has already been indicated, it is the actively growing

green grass and the hay that maintains its green color that give high vitamin potency to milk.

"A further interesting observation along this same line is that of Koessler and Maurer, who assert that vitamin A is essential for normal blood regeneration, and that there is a definite relationship between a state of chronic vitamin A deficiency and certain anemias of man.

Experiments With Types of Milk

"The first series of experiments were planned to compare several types of grades of milk, these grades being (1) certified milk, four percent, (2) the milk from cows fed upon a special feed mixture, 4.4 to five percent, (3) the commercial market milk, 3.8 to four percent. The herd from which the certified milk was obtained was at the time of the experiment receiving a warm diet of ground first-grade alfalfa hay and grain which were hydrolized and predigested, to which a complex mineral mixture consisting of bonemeal, blood meal, copper sulphate, manganese iodide, iron sulphate, arsenic, aluminum chloride, and zinc chloride was added. The special milk came from a herd receiving a liberal dry grain ration plus an abundant supply of first-grade alfalfa hay and the mineral mixtures as above with the addition of dry fish meal. The third source was commercial milk obtained from a market in the vicinity of the laboratory. The diet of the cows producing this was entirely unknown but may be assumed to be that of the average dairy cow. These experiments extended over a period of five months, and as the time advanced it became more and more evident that the various groups of animals were not developing equally. The control group, those being fed upon the milk of the cows receiving the special feed were all in good condition with sleek coats, clear eyes, playful and of gentle disposition, while those fed upon the market milk were dull, listless, irritable, with rough coats and dull eyes. The weight curves and the blood counts also showed variation.

"At the end of five months, the average changes were as follows:

	<i>Red Blood Cells</i>	<i>Gain in Wt.</i>
Control Group.....	Gain 3,200,000	55 grams
Certified Group	Gain 2,700,000	57 grams
Special Group	Gain 2,000,000	88 grams
Market Group	Loss 1,700,000	33 grams

"This experiment was repeated upon three other series of rats, and in each experiment these results were duplicated to a surprising degree. During each of the tests it was noted that the rats receiving the market milk consumed more milk per rat per day than those receiving the

special or certified milk; yet, as indicated, their growth was retarded and they became anemic. In one experiment a group of six young rats averaging 20 grams in weight and with an average red cell count of 5,500,000 was placed upon the special milk diet for a period of 98 days. At the end of this time the average weight was 110 grams and the red blood count 9,700,000. They were then placed upon the heated market milk for 124 days. During this entire period the weight increase was but 15 grams and the red blood count indicated a loss of 5,900,000 cells. These same rats were again placed upon the diet of special milk for a period of 90 days during which there was an average increase of 57 grams and a regeneration of red blood cells until the normal count of 9,600,000 was again reached. These rats were again given a diet of heated market milk for 37 days. At the end of this time the group had lost an average of 37 grams in weight, and the red blood count indicated a loss to 5,800,000 cells. Thus by varying the diet from the special to the market milk, it was possible repeatedly to retard or accelerate the weight and to increase or decrease the red blood count to a marked degree.

“Further experiments were also reported in which two portions of the same sample of milk of the cows on the special diet was used, one portion being heated to 62 degrees C. for 30 minutes; the other unheated. The results of this test indicated a loss of 21 grams in weight and six percent in hemoglobin, with a decrease of 1,200,000 red blood cells in those fed the heated fraction.

“A further experiment indicated that the addition of cod liver oil and tomato juice to the diet of commercial milk did not increase its nutritive value sufficiently to equal that of the milk from the cows upon the special feed.

“In a subsequent series of experiments the animals used were weanling rats who had never tasted food other than their mother’s milk. These rats were divided into groups of six each. The first group was the control, receiving a normal diet of grain, vegetables and bread. The second group received the herd milk unheated. The third group was fed the milk of the same herd after it had been heated to 145 degrees for 30 minutes. A fourth group of rats was fed upon the usual dry winter feed and had no grass or other green food during the time of the experiment. The fifth group of animals in this series was given the milk of cows who were upon official test and who were producing from 90 to 100 pounds per day during the period of observation.

This experiment was of comparatively brief duration, extending over a period of only 11 weeks, and yet in this short time rather striking results were obtained. The rats used as experimental animals were all born within a period of three days and all closely approximated 42.5 grams in weight and a blood count of 5,300,000 red corpuscles when weaned. During the period of the experiment the following results were noted:

	<i>Red Blood Cells</i>	<i>Gain in Wt.</i>
Control group	Gain 4,700,000	113 grams
Unheated herd-milk group.....	Gain 2,340,000	100 grams
Heated herd-milk group.....	Loss 2,340,000	66.5 grams
Winter-feed group.....	Loss 2,480,000	12 grams
Official-test group.....	Loss 3,600,000	9.5 grams

"The herd used in this series of experiments was obtained from a Holstein herd fed warm hydrolized ground alfalfa hay and grain diet similar to that used in the series of experiments previously reported. Mineral mixture, however, was omitted as was the fish meal. The cows upon "winter feed" received a dry grain mixture of corn, oats, oilmeal, and cottonseed meal with a poor quality of brown hay (timothy and clover) and a small amount of silage. The cows upon official test were fed the warm ground feed as used in the general herd but were fed to their capacity. The animals fed upon milk from these test cattle showed early lack of growth and vitality and at the end of six weeks three of the group died. The other groups of this series showed rather wide variation in weight and in the red blood count. The control group and the group fed upon the unheated portion of the general herd milk developed in an entirely normal manner, while those upon the heated portion of the milk from the general herd and those fed upon the milk from the portion of the herd kept upon winter feed presented well-marked anemia.

"At the conclusion of this experiment the rats of groups three, four and five, or those which had received the heated herd milk, the milk of the cows upon the winter feed, and the rats that had been rendered anemic by the use of the milk from the high-producing cows, were removed to another laboratory and placed upon a diet consisting of the unheated milk from a herd that was receiving a liberal dry-grain ration plus minerals and fish meal, supplemented by an abundant green blue-grass pasture. To this changed diet the experimental rats showed a quick response and within a 40-day period showed the following gains: The group previously on heated milk gained in weight an average of 51 grams and an increase of 5,000,000 red blood cells. Those formerly

fed on milk from winter-fed cows made an average gain of 63 grams and an increase in red blood cells of 5,500,000. The rat from the group fed upon the milk of the test cattle gained 108 grams and 6,700,000 red blood cells in 71 days upon a diet of this special unheated milk, with lettuce occasionally during the first 30 days.

"In a still later experiment in which the same general methods of procedure were followed as to animals, cages and food of the experimental animals (rats) were carefully maintained, different results were obtained. This experiment was started October 17, 1931, and the milk used was from the same herd that had given such excellent results during the preceding months. During the progress of this test, however, the rats failed to respond in growth and showed both loss of erythrocytes and hemoglobin. This condition became more noticeable during November and was quite marked during December. In seeking an explanation, it was found that the herd producing the milk had been upon a failing pasture supply during October and November, and that in December they were entirely upon a ration of dry grain, a mineral mixture, fish meal and silage. The hay, however, which was thought to be first quality alfalfa had heated in the mow and was bleached and brown. This result was in all regards similar to that obtained from the milk of the so-called winter-fed group of the previous experiment and corresponds closely with the results of Krauss, Erb and Washburn.

"Changes were instituted in the feeding of the herd producing this milk. A first-grade furnace-dried alfalfa meal was obtained, the silage was withdrawn, and the hay was hydrolized and malted as in the earlier experiments. The grain and mineral rations were not changed. With this change of feed the milk of these cattle soon regained its growth and hemopoietic properties, and rats that were already anemic gained 2,000,000 red blood cells and 43 percent hemoglobin in a period of 26 days. Again in this experiment it is strongly indicated that the factor in milk concerned with growth and hemopoiesis is entirely dependent upon the food and the feeding methods, especially with the quality and pigment content of the hay.

"In association with this last series a number of what may be termed purely laboratory experiments have been conducted in order to find if possible what, if any, substance might duplicate the action of this unknown factor of milk which stimulates blood regeneration. Carotin, because of its close chemical relationship to hemoglobin, was chosen first, and a sample of this material was obtained through the courtesy

of the Digestive Ferments Co. of Detroit. This substance used alone in the milk in doses of 0.1 mg., later increased to 1.0 mg. per rat per day, was at first thought not to be giving the expected results, but more prolonged investigation of its properties indicates that, although it is somewhat slow in its reaction, it ultimately gives satisfactory results, in our series giving a count of 7,000,000 corpuscles and 90 percent hemoglobin in 90 days. Following the work of Olcott and McCann, who have so recently proved that carotin is converted into vitamin A by enzymatic action of the liver, it was decided to add as nearly as possible a pure vitamin A to the deficient milk diet of already anemic rats. The material used in this experiment was the pure halibut liver oil to which no vitamin D had been added. This preparation was kindly furnished us by the Research Department of the Parke-Davis Co. This material was used in amounts of two to three drops per rat per day and gave marked results, increasing the number of red blood cells 2,500,000 cells and a gain of 46 percent hemoglobin in a period of 24 days, and with also an active regeneration of hemoglobin.

"To the diet of other anemic rats there was added an alcoholic extract of furnace-dried alfalfa hay. This extract had been evaporated to dryness and redissolved in olive oil. This extract was given in doses of five drops per rat per day and was estimated to represent three grams of the original hay. Chemical analysis of this alfalfa extract shows that the daily dose of iron was .00171 mg., that of copper .00135 mg. Beard and Myers state that the minimum dose of iron necessary to stimulate hemopoiesis is .25 mg. of iron and .025 mg. of copper. It may be seen, therefore, that the dosage of iron and copper in the extract is far insufficient to supply the minimum amount established by these workers. In this group of experimental rats again there was observed rapid regeneration of both hemoglobin and erythrocytes, these animals showing an increase of 3,000,000 cells and a 41 percent gain in hemoglobin in 26 days, while the group that was placed upon the basic (or control) diet in the same period of time gained 1,700,000 cells and 46 percent hemoglobin.

"Other substances are being tested, but thus far none has given such favorable results as those mentioned. These will be the subject of a later report. The results of the work done in this laboratory tend to confirm the conclusions of Guha, who states that: 'Both milk and yeast contain a factor that is required for the normal growth of rats.

"The factor present in milk is different from other known vitamins, A, C, D, E.



Top rat received an exclusive diet of milk upon the special feed mixture described. Middle rat received milk from the same herd fed the usual "winter ration." Lower rat is the same as the one in the middle 40 days after the diet was changed to milk of a herd feeding upon an abundant grass pasture.

"The milk factor can not be corrected by lact-albumin or amino acids.

"The milk factor is thermolabile at high temperature, which argues against its inorganic nature.

"The factor is present in egg, spinach, grass and alfalfa.

"Carotin and chlorophyll do not replace the milk factor in the diet."

Conclusions From Rat Experiments

"1. Experimental proof is presented that the nutritional anemia of the white rat may be relieved by either (1) the feeding of the milk cows fed in the manner described, or (2) by the addition of an iron and copper free extract of alfalfa, or (3) by the addition of a liver oil high in vitamin A to the deficient milk diet.

"2. This growth-promoting factor is absent or insufficient in the milk of cattle fed upon the usual winter dairy ration.

"3. This factor, when present in milk following the special feeding of the cattle, is thermolabile.

"4. Further evidence has been obtained of the intimate relationship existing between the feed of the cow and the hemopoietic factor or factors in the milk.

"5. Milk, to be of the highest nutritive value, must contain the factors resulting from the presence of the vegetable pigment in the food of the cow.

"6. The rapidly growing belief in the close association between the vegetable pigments, carotin and chlorophyll and vitamin A or its associated factors is strengthened by these experiments."

At this time the authors agreed upon the great value of feed and environment as necessary protective agents in the body of the animal. Diseases are therefore not all primarily direct infective processes, but it is common to change the already existing bacteria in the body through what may be called the lowering of the protective agencies and chemical status. Thus disease organism already present are given opportunity to develop. This may be brought about through deficiencies.

Cod Liver Oil As a Substitute For "Green"

To demonstrate the value of carotin (or vitamin A) equivalent in the "green" in the ration, Mr. Bonnell, having undesirable hay, began feeding his cows cod liver oil (600 vitamin A units and 330 vitamin D units) in the ration. Mellanby in England had just discovered (1928) that carotin of green hay is the precursor of vitamin A. The results of

this trial with cod liver oil revealed a higher percentage of butterfat but a smaller volume of milk. It improved the condition of the animals as shown by the fact that better and stronger calves were reared. Cod liver oil with 2000 vitamin A units and 100 vitamin D units is now being used.

We thought possibly the continuation of cod liver oil in the feed for calves might be helpful in maintaining and raising the blood hemoglobin since green alfalfa hay, which has abundant iron, was included in the ration. This prediction was found to be correct.

The Value of Vitamin E

The hay was ground and mixed with milk, displacing bran in the feed of some of the calves, while others were fed both bran and alfalfa with milk. The bran used was the "old-fashioned", not degerminated. The resulting physical condition of the two groups indicated that the calves fed on bran and alfalfa later developed and bred satisfactorily. We knew of the comparative value of old-fashioned bran and degerminated bran, for we had discovered that cows in herds getting large amounts of the old-fashioned bran were less likely to be sterile than those fed degerminated bran. We then obtained from Dr. Price, of the Pillsbury Laboratories, pure germ of wheat for calf and heifer feeding and later, when the price permitted, we fed it to cows. We now understand that germ of wheat provides a large amount of vitamin E and some G and also another factor which has not yet been thoroughly described but which in combination with "green" seems to influence breeding. Vitamins A, E and G combined with proper proteins and minerals, which we have long thought desirable in a feed ration, are becoming more widely recognized as essential factors in the diet. We have been using them in calf feeds in combination with liver meal for nearly 20 years with excellent results. Therefore, the "green" of the grass (either green or properly dehydrated) which possess all these factors should be given throughout the year.

Drouth Cattle Feeding Test

More evidence of the value of "green" was convincingly demonstrated when a group of nearly 28,000 cattle was brought to Delaware, Ohio, from the drouth-stricken area of the West during the summer of 1934. They had not had green feed for some time, and according to reports 29 percent of these cattle were blind in one or both eyes, indicating in many instances an ophthalmia due to vitamin A defi-

ciency. Much green corn was fed and many of the acute cases improved and some were cured.

A similar condition presented itself on some of the saddle horse farms in Kentucky a number of years ago after an extreme drouth during the spring and summer. This was known as "moon blindness."

Burgie of Leipzig and his co-workers recommended chlorophyll and vitamin A not only in ophthalmia but also in cases of tuberculosis, cardiac disease, anemia and arteriosclerosis because of the "tonic" benefit.

CHAPTER XXIX.

HAY PRESERVATION

FROM all these experiences it is evident that the preservation of "green" in grass is highly important; but long before many of these conclusions had developed, we had begun to devise methods of preservation of these constituents. We thought we had reached a successful development in 1917 by drying green hays by means of a mechanical drier immediately after they were cut. There were some disappointing events, the chief one being that the chlorophyll, carotin and the xanthophyl were lost to such a great extent that we questioned whether the increased nutrition resulting from this drying operation would compensate for the increased cost of drying the hay.

We found as early as 1914 that by using the products of combustion, particularly carbon dioxide (CO_2) and nitrogen gas in the drying operations, oxidation was prevented and nutrient preservation was increased (particularly carotin). We still did not retain the chlorophyll through this drying operation, and we found that heat and moisture were the chief destructive agents. This was discouraging for we found that destruction of chlorophyll began at temperatures as low as 120 degrees F., while under certain conditions it was destroyed at 200 degrees and at 240 degrees it was completely destroyed in all cases.

This led us then to the preservation of hay with gases, which we had attempted as early as 1905. Owing to the decrease in price of some non-oxidizing gases and with improvement in refrigeration, we attempted in 1928 to refrigerate green hays. However, we have also made improvements in driers using the double unit system, in which case the drying operation is carried on by bringing high temperature gases into contact with wet green hays at temperatures ranging around 325 degrees, by blowing them through the hay by means of a stirring apparatus. Evaporation was so rapid that the temperature of the hay remained as low as 150 degrees. In making hay with a predrier, about 50 to 55 percent of the water is driven off, and then with moisture content reduced one-half, it is easy to dry hays at temperatures as low as 180, thus preserving much of the chlorophyll. Investment in such drying apparatus is impossible for the average farmer but practical for a group of farmers. Our new method of using dry ice with green hay in big preservers is a cheaper method of preserving these factors, and the investment of installing such a preserver is within the reach of

most farmers, but we find these preservers now are practical only for fall hay.

It has long been known that (as brought out in previous pages) young grass is of great importance in feeding dairy cows, for nearly all the factors of nutrition that make for reproduction and for a more nutritious milk are in the immature green grass grown on properly fertilized soils. As grass matures the minerals, vitamins and carotins are reduced; and the proteins and carbohydrates are changed. While grass provides the nutrients in summer, it has seemed impossible to preserve these nutrients for winter feeding.

First Attempts at Preservation

Various methods have been attempted. About 28 years ago, we tried preserving the nutrients in young green grass by ensiling it such as the Dutch system. This attempt was unsuccessful on account of formation of obnoxious odors. Our second attempt was to mix green grass with cornmeal in the silo to generate carbon dioxide gas (CO_2) and thereby preserve the grass. This was more successful than the previous method, but did not produce a palatable feed.

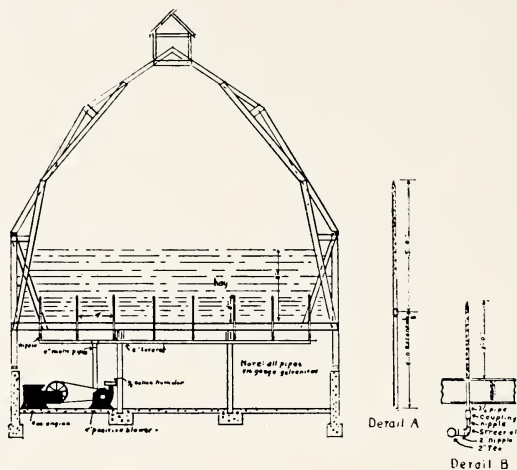
Our third attempt was to mix green grass with corn sugar. Although this was more successful than the first two attempts, we still did not consider it satisfactory. Molasses was considered practical as a preservative agent but we had difficulty in mixing such a gummy material.

Next, we endeavored to preserve the nutrients of grass with citric acid and corn sugar. We were disappointed in not being able to produce a good-flavored silage and the process was too expensive. The fifth trial was to use lactic acid, and this was successful and likewise was expensive. Our next trial was to use hydrochloric acid at the rate of 10 pounds to a ton, which made the grass unpalatable and an unpleasant resultant odor was found in the milk produced by the animals. Besides we had to feed neutralizing agents such as soda and lime. Our next attempt was to blow the products of combustion from a charcoal furnace through the hay placed in a silo. Due to lack of uniformity in the distribution of the gases, this method was not acceptable.

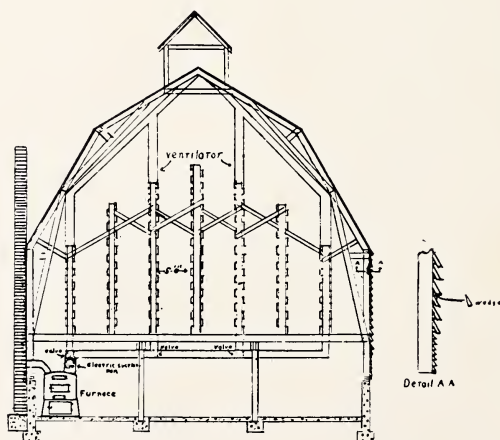
The First Hay Driers

Due to our lack of success with ensiling green grass a process of drying was resorted to. Dairymen in those early days (about 1900) appreciated the fact that alfalfa and other hays differed nutritionally,

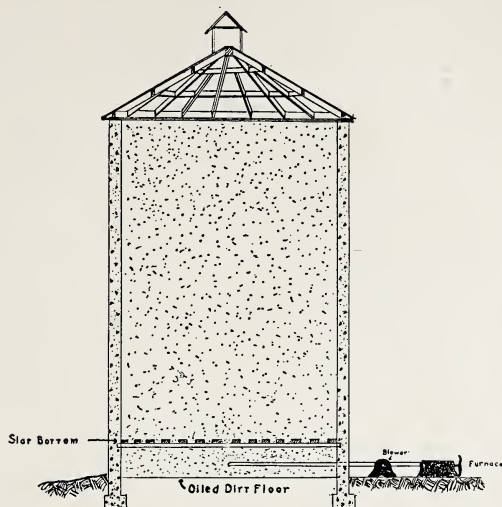
FIRST ATTEMPTS AT DRYING GREEN HAY ARTIFICIALLY
IN THE BARN (1904)



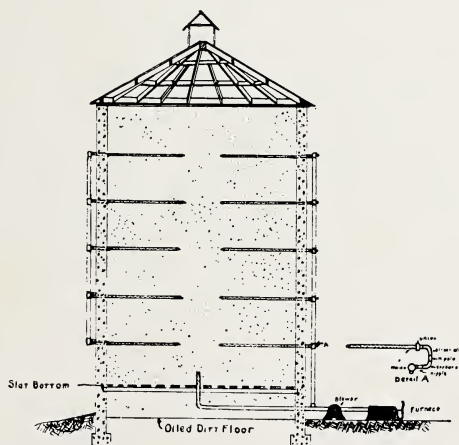
PERFORATED PIPES ARE PLACED THROUGH THE HAY AND AIR AND
GASES ARE PUMPED IN THEM.



FIRST TRIAL IN HAY DRYING THROUGH FLUES PLACED THROUGHOUT
THE MOWS.



ROUND BARN DRIER—THE FIRST ATTEMPT TO PRESERVE GREEN GRASS IN A SILO BY MEANS OF HOT FUEL GASES.



ANOTHER ATTEMPT TO DRY GREEN GRASS BY MEANS OF INTRODUCTION OF HOT FUEL GASES INTO THE GREEN HAY IN A SILO.

and that common dried hay lacked factors contained in fresh green grass. At this time we began an experiment at the Kansas Experiment Station which convinced us of this fact and led us to continue our efforts at hay preservation.

We selected six cows, three of which were fed freshly mown green hay and the others, the same grass after it was thoroughly dried. The thought was that the hay should have the same nutritive value as the grass from which it was derived; but this was not true, for the cows receiving freshly mown hay gave an average of 28 percent more milk than those fed the same kind of hay sun dried.

Apparently there was something lost by the sun-drying operation. This hay was made from alternate swaths—one swath sun dried; the other fed immediately. The time factor was excluded because later the group which was first fed green grass was placed on the dried grass, and likewise the second group was placed on green grass. This hay which was fed after going through the ordinary process of fermenting (or what is ordinarily called sweating) in a mow reduced the milk production 44 percent.

This led us to retain by dehydration some of the nutritional constituents which are lost in the ordinary curing process. It was easily realized that in the high nutritional young grasses which the cow gets by pasturing were factors that could not be determined chemically but were in evidence physiologically both from the appearance of the animal and in the quantity and quality of her product.

To conserve these principles our first attempt was to dry the hay over a screen, using gases of combustion from a long furnace flue, and later using steam pipes under the screen with a fan blowing the air over the steam pipes up through the hay. We found that the presence of carbon dioxide preserved many of the vitamins and the flue gases preserved the hay well if there was a small percentage of carbon monoxide present. While this work seemed impossible to put into practice, we did build a blowing system in an ordinary barn in which we blew hot air from a small furnace through hay in the mow. We began to realize that the small amount of air we were forcing through the hay by means of a pressure blower did not overcome the rapid fermentation which ordinarily develops in a hay mow, especially if the hay put into the mow contained 24 to 30 percent moisture. A larger pressure blower made this practical, and later by the introduction of more carbon dioxide into the air the hay remained well pre-

served in the mow. The expense for the volume of hay dried was, however, too great. This experiment carried out in 1906 is reported in the Kansas Farmer and Kansas State Agricultural report.

More recently vertical bin driers have been built. They are 20 feet high, 20 feet long and four feet wide with a four-foot space 16 feet high left in the center. This space is so made that all air passing from it must go through the hay on either side. At the base a 48-inch propeller fan, operated by a four horsepower motor, forces hot air into the drier. This drier involves less capital and is practical for farmers, especially those feeding their own hay. The vitamin content of this hay varies with the rapidity with which the air and carbon dioxide mixture are forced through the drier. If the hay is dried in less than 18 hours by first heating to 160 degrees and then cooling it to normal temperatures a high quality hay is obtained.

The drier mentioned can not be compared with the regular mat drier in which hay is dried with air at slightly less than 2000 degrees for eight minutes and is then immediately cooled. Where it is necessary to remove water to 40 percent, such as in the bin or mow driers, a rapid deterioration takes place within two to four hours. This depends upon air conditions. Hence under humid conditions after showers or rain, drying hay in the field to 40 percent water content often destroys many of the vitamins and plant hormones, thus interfering with the nutrition of the hay.

Drying in the Bale

Numerous other early designs might be recorded here, but they were mostly impractical. In the irrigated country of western Kansas and eastern Colorado in 1905, attempts were made to bale out of the swath, and the hay was then cured by setting the bales on end in the field. In some years when the winds were dry this proved to be successful, but as a rule it was a failure. Also, hay was gathered and so piled under sheds that air could circulate between the bales. In many instances even with this precaution the hay in the center of the bale completely lost its nutrition and became practically worthless. Of late, however, Mr. Fulmer of Nazareth, Penn., has developed a baled hay drier, constructed with a fan which forces a large amount of air under slight pressure through the bales. The success of the baled hay drier depends somewhat on the moisture content of the hay at the time of baling. The more moisture in the hay at the time of baling the more difficult is the drying operation.

To overcome some of these difficulties of baling hay out of the swath, which was moist enough to mold and produce a brown core, we devised in 1914 a scheme of introducing carbonic acid gas into the center of the bale. This was a complete success, but owing to the fact that it took from \$3 to \$4 worth of carbonic acid gas per ton it was considered too expensive for practical purposes. In the second trial we attempted to check the fermentation with nitrogen, which was cheaper at the time. However, it took still more nitrogen gas to prevent fermentation and hence was even more expensive than the first method. Chlorine gas was required in the smallest amounts and was the cheapest, but chlorine interfered somewhat with the nutrition of the hay as determined by observation, and the cattle did not like the hay so well even though it was quite green. Carbon dioxide was apparently the most successful of the three from a nutritional standpoint, and in 1927 our first attempt was made to place cubes of dry ice (which is solid carbon dioxide) into the center of the bale. The bale was then cured in ventilated sheds, as in the other cases of gas curing. This was a complete success except that the cost was prohibitive at the time. Since the cost of dry ice is lower now, we have developed a number of new methods for the preservation of green hays, the success of which is reported in later pages.

Fletcher squeezing rolls attached to a mower for the purpose of squeezing out the juice of the hay immediately after mowing have apparently not been practical up to the present time.

The most neglected part of drying hays from the fresh green swath is that of gathering the hay from the field while in a heavy moist state. This naturally becomes one of the expensive problems in hay drying. Drying depends upon the degree of moisture in the hay or the length of time it is left in the field. It is necessary to haul three loads of water in order to have one load of dry hay. However, where hay is allowed to remain in the field for a short time until the moisture content is reduced 40 to 50 percent, transportation from field to drier becomes less expensive. The cheapest way of handling wet hays from field to drier was formerly by means of a heavy buck rake. This is practical only where the drier is located in or close to the alfalfa field. Pitching green hay by hand out of the swath is difficult and impractical. The next practical plan was to load the green hay with special heavily made loaders out of windrows, which were made by a well-constructed side delivery rake. Mason originally had devised a mower that not

only cut the standing grass but also cut the stems into short lengths and by means of a carrier delivered these short lengths into a wagon. This scheme saved all the leaves and prevented the inclusion of dried stems from previous cuttings and dried manure which frequently happens when the grass is raked up. This did not give an opportunity to remove the first 20 percent of moisture from the hay, which ordinarily can be done within one hour of good drying weather without any marked injury to the nutrition of the hay.

Other Methods of Hay Drying

Duffee of the Wisconsin Experiment Station conceived the idea of windrowing the hay a few hours after mowing and with a machine that consisted of a cutter, a stub loader and a blower automatically rake the hay, cut it and blow it on a wagon. The hay could then be delivered and dumped without hand labor into a drier. This particular machine is now manufactured by the Fox River Tractor Company, Appleton, Wis. Mr. Duffee is now carrying on research work in an effort to determine the best method of drying hay in bins similar to those already described.

About this time the Indiana Experiment Station devised a means of ricking hay on tripods, forming a stack of hay over the tripods. Air from a blower attached to an oil furnace was blown into the tripod beneath the stack, thus causing the hay to dry. The drying depended to a great extent upon making the layers uniform throughout the stack so that air uniformly penetrated the hay. Rick drying too had been employed in the South to dry peanut hays. However, the humidity of the air and rains are uncontrollable.

We in 1908 devised a portable rick which consisted of tripods set on a platform, over which was fastened a rope net, the ends of which hung down over the end of the tripods. Regular hay fork releasing hooks were placed at the top of the tripod so that these ropes could be used in connection with a hay fork in pulling hay up into the mow after it was dry. To the mower was attached an elevator by which moist hay was placed on the back of the ricks. These portable ricks were frequently put under sheds where the green hay was allowed to cure before being taken to the mow. The plan proved to be burdensome and impractical.

Following this (1918) we began to build bins four feet wide with 18 inches of space between the bins in barns. Hay was cut and blown into these. Hays containing more than 30 percent moisture heated

and discolored if allowed to cure naturally. By enclosing one of the 18-inch spaces between the bins and forcing air at temperature of 160 degrees through the two four-foot walls of hay on both sides of the 18-inch space and allowing it to discharge into the space between, hay containing 40 percent moisture could be dried and cured well with a fan delivering 5000 feet of air per minute. The air had to be blown through the hay for 60 hours to dry it thoroughly. Hay dried by means of forcing hot air through walls of hay seemed to have a higher nutritional value, judging from the appearance of the cattle and the amount of butterfat produced, than did hay dried to 30 percent moisture in the field and then brought in and allowed to cure naturally. While we do not contend that this observational work was equal in accuracy to laboratory practice, it guided us somewhat in a direction which seemed to be contrary to common practice.

We did not understand at that time the liberation of the nutritive factors or the chemical changes that occur during the various preserving processes. The great handicap in all our work then was rapid heating of the hay immediately after cutting, and we began to recognize the value of some principle which prevented the hay from oxidizing.

Our next experiment was to blow green hay into a concrete silo by means of a large high pressure blower. The gases of a combustion furnace were blown simultaneously into this silo, carrying out much of the moisture of the hay. This we felt would check fermentation. While this can be accomplished it took considerable power and expense to dry the hay, that is, to run a steam engine, to furnish gases and generate power to blow 20 tons of water out of a 10x25 foot silo in order to get eight tons of dried hay. Only a fraction of an ounce of moisture is carried out for each cubic foot of air and gas. Most of these experimental developments are illustrated in *The Ohio Jersey* (1925).

Modern Driers Tried

Realizing by this time that it was the "green" of the plant that was the important constituent which we were losing and that it probably contained most of the nutritional factor, we chopped the hay and ran it through a grinder. The green juices were extracted and mixed with bran. From an observational standpoint this proved to be a desirable feeding mixture. This led us to the dehydration of the "green" of the plant for the purpose of preserving the nutrition. The residue from the hay was mainly cellulose and from this paper was

made under our own patent. However, drying of the juices gummed the rollers in the drying machine so severely that it was impossible to dry them except through a spray system which was quite expensive. However, in a small silo we did dry some by means of the spray process for experimental work. The method has been abandoned but still has possibilities.

There was also a drier built by the Brown Paper Company, Berlin, N. H. It was used near West Palm Beach, Florida, for the purpose of drying peanut hay. The drier consisted of a long conveyor belt within a tunnel. Fresh hot air from a gas flame was introduced from the sides. This reinforced the already saturated air in the drier, giving it greater moisture-carrying capacity and preventing it from dropping the moisture of the hay after it was cooled. The same principle is used in a number of driers in California. While the method is effective the investment is high and the cost of drying is great, which always becomes a limiting factor in hay drying operations.



FIRST MECHANICAL HAY DRIER MADE BY JEFFREY
MANUFACTURING COMPANY.

The Jeffrey Manufacturing Company of Columbus, Ohio, in 1911 developed a rotary drier for the purpose of drying pea vines, which were a waste product at canning factories and which contained a high percentage of proteins and minerals. Due to the fact that the heat striking the falling material in a 30-foot drum caused the hay to lose some of its nutritional factors and because it became difficult to control the temperatures so as to prevent burning and charring of the leaves, the idea was abandoned. However, this same kind of drier is now being used at the Louisiana Experiment Station with a slight modification, that of properly controlled oil burners and a reversed air current which make the drying more practical. Previous to this we had discovered several farmers, one particularly at Mt. Gilead, Ohio, who dried corn stalks in a Pillings Tile Drier.

After the Jeffrey drier was abandoned Mason began to develop a screen drier similar to the Pillings Tile Drier except that he had patented an eight-inch matting machine which delivered an eight-inch mat of hay upon the screen of the drier.

Koons of Louisiana then conceived the idea of heating the hays to high temperature for a short time. With this process he made good hay and dried it in 40 seconds at 2700 degrees. No tests were made of this hay but from all appearances it seemed to possess the important nutritional factors necessary for the production of good milk and reproduction. While high heat is extremely detrimental to hay, the short exposure of heat to the hay undoubtedly made is possible to retain the nutrients to a great extent.

Later the Arnold drier was developed. It blew hay through a cylinder similar to the Jeffrey drier but reversed the direction of the hay through two internal chambers. Hot air circulated with the steam of green hay at a temperature of from 1800 to 2000 degrees for several minutes. This hay was never tested, but the hay must undoubtedly be of good quality.

Also, about this time a drier was developed by Mr. Murphy, a New York engineer, at the White Swan Farm, Erie, Pa. The object of this machine was to squeeze hay between two rollers, after which it was swelled with live steam and then dried by steam heat. The heated rollers began to gum on the surface, and the steam expansion of cells in the hay changed the nutrition; and the whole drier was more or less impractical. This drier was then revamped by George B. Taylor and L. H. Moulton, owner and manager, respectively, of White Swan Farm, who used fuel gases for drying and put in side fans which would draw the gases through the hay and force them down into the next chamber. This plan of forcing hot gases in five stages through a mat of hay became a practical method of drying and made a hay with a high nutritional value, provided the temperature was kept down to 200 degrees when discharged into the expansion chamber. These two men have contributed much to the science of hay drying.

Charles Michael also became interested in the manufacture of a vertical drier in which hay was moved on circular plates in a spiral motion through a vertical drum. This dryer was quite successful on a small scale.

Several new developments became evident at this time: first, that hay dried in a mat retained its nutrition to a greater extent; and, second, that the heat discharged into an expansion chamber and moderated by fresh incoming air prevented burning because of the slower air flow and greater hay surface.

Fulmer of Nazareth, Pa., was likewise developing a drier which circulated air through a mat of hay. The hot air was forced up and

down through hay in the drier, and the moisture-saturated gas was discharged where the green hay was entering. This proved to be a desirable drier. It introduced the necessary idea which we had discovered early in hay drying, namely, that when flue gases and air were forced through a mat of hay the carbon dioxide was absorbed by the hay and this prevented the liberation of vitamin C.

The Randolph Dryer Company of Toledo, Ohio, built a drier which instead of forcing the hot air through horizontal chambers forces it through a series of mats of hay, the mats being reversed several times. Thus the driest hay came in contact with the hottest air. This is a mechanical improvement and at the same time, with low temperatures, maintains much of the food value in the hay.

In 1932, we questioned the feasibility of cutting hay, putting it into swaths and allowing it to dry just so long that it lost but little of the chlorophyll and carotin. About four hours on a good dry day was required for this process. This hay was then brought up and run through a cutter and put in loosely woven bags. These bags were piled on a sweet corn drier screen. Those bags that were moved and dried quickly gave us splendid results, but those which were left to dry too long lost both the chlorophyll and carotin.

We then proceeded to dry the hay with a hammer mill, which was a difficult process because we did not have a screen with a sufficiently large opening to allow the moist hay to pass through. By this method, it required two operations in order to pulverize the hay. We extracted about 20 percent of the moisture and then put the hay into bags after which it was dried over drying screens.

There is a possibility that some time we can attach three hammer mills in a row, using large cyclone driers at each mill to dry the hay to the extent that it contains about 32 percent moisture. We found that this was about the limit for the amount of moisture the hay could contain to be pulverized satisfactorily in the bags. The bags should be piled loosely on a well-ventilated barn floor. Hay that is cut in inch lengths can be cured with 37 percent moisture in the hay in bags.

Thus far in our attempts we have encountered heavy expenses for machinery or large labor costs. There is no way in which we can make hay as cheaply as by making it in the field in the old-fashioned way and yet retain all the desired nutrients. In other words, it costs (and in some instances considerably) to preserve the important nutritive factors in green hay.

Preserving Green Hay With Dry Ice

A receiver was built in 1935 by the William Bayley Company, Springfield, Ohio, like a galvanized iron silo except that it was gas-tight in order to hold about 22 pounds of pressure per square inch. This so-called "green hay storage tank" was opened January 11, 1936, and the hay was found to be in practically the same condition as when it was stored. This experiment has probably been the most successful (from the standpoint of good flavored hay) of many which we have carried on up to this time attempting to preserve the "green" of hay in a practical manner. However, we lost some carotin in the hay at the top of the tank by this method.

We have tried to dry hays in order to preserve chlorophyll, xanthophyl and carotin, at the same time having the minerals in proper relation with proteins, carbohydrates and fats; and we have been quite successful except in the preservation of chlorophyll. When temperature of 135 degrees F. is exceeded for one-half hour, we have found (with the help of Dr. O. L. Inman of Antioch College, director of the C. F. Kettering Foundation for Study of Chlorophyll and Photosynthesis) that chlorophyll deteriorates in proportion to the length of time the hay is exposed to the temperature. When green fresh hay is subjected to temperature of 160 degrees for 20 minutes, the result is practically equivalent to subjecting it to 135 degrees for 1½ hours.

The limit of practical drying seems to be at temperatures ranging from 180 to 190 degrees for 30 minutes. The chlorophyll is decidedly changed at 200 degrees. However, hay dried at temperatures of 180 to 190 degrees retains the xanthophyl and carotin to a high degree. In an ordinary brown hay that is taken out of the mow, the chlorophyll and the xanthophyl are completely lost and only a comparatively small percentage of the carotin is present. While a large percentage of the proteins, carbohydrates and some fats are still available for nutrition, the metabolization of the minerals is interfered with due to the loss of vitamins and enzymes.

We made an attempt in 1928 to freeze green hays for the purpose of preserving all the nutritional factors found in the growing hay. The hay was placed in barrels and put in a freezer at a temperature of 10 degrees F. The hay was stirred in the freezer in order to cool it rapidly. After this the hay was placed in barrels, removed from the freezer, and kept at a temperature of 25 degrees F. The hay came

out of the barrels six months later in perfect condition other than being slightly limp after being thawed out. However, it had to be fed within four or five hours after it had thawed, since deterioration set in rapidly at ordinary stable temperatures. The chief objection to this method of preservation was the expense and the inconvenience of the packing and removal of the hay from the receivers. However, we had designed a structure something like a silo which was insulated on the outside and had expansion coils on the inside against the walls. We found that it was necessary to lower the temperature of hay to the freezing point before putting it into this structure because of the insulating or non-conductive effect of loose green hay. We have experienced this insulating effect even in the barrels when the uncooled hay was packed. In these cases, the hay in the center of the barrel was slightly fermented. Hay cut in lengths of from one-half to three-fourths inches and allowed to lie on a pile or put into a barrel begins to heat within an hour and one-half. This is due probably to the oxidation and the activity of the remaining living plant cells, combined with the effect of enzymes.

These experiments led us to conclude that perhaps hay could be equally well preserved by using carbon dioxide and nitrogen gas in barrels and putting them at temperatures of 40 degrees. When hays were cooled and the gas was directly introduced, a perfect condition was maintained. This was especially true when nitrogen gas was used.

We had first mixed dry ice (which is congealed CO_2) with hay in 1933. This had the pre-cooling effect and at the same time it gradually liberated CO_2 gas. Simultaneously we pre-cooled a second barrel while a third barrel of hay was not pre-cooled but into both nitrogen gas was introduced. In a fourth barrel, chlorine gas was used. All these barrels were kept at a temperature of 40 degrees F. The hay mixed with dry ice was in perfect condition after six months of storage. The hay in the second barrel was in extraordinarily good condition, but the third barrel (not pre-cooled) showed a deterioration in the center. The hay mixed with chlorine gas showed a marked deterioration of chlorophyll, indicating that we had used entirely too much chlorine gas.

Later we thought that probably by placing 10 pounds pressure per square inch on the barrels it would allow us to use high temperatures. Consequently, one barrel was filled and the equivalent of 50 pounds of dry ice to one ton of hay was used. With a pressure of

10 pounds this hay seemed to be well preserved at the end of a five and one-half months' period at 55 degrees F. storage temperature. The hay in this particular barrel had the characteristic fresh aroma that green grass usually has and was similar to the odors we got at low temperatures with nitrogen gas as the preservative. Owing to the expense of pre-cooling the hay, we abandoned the nitrogen experiment although it left the hay in a splendid condition. We tried the chlorine the second time, introducing one part to two million and kept it at 55 degrees F. In both tests with chlorine we were unable to develop a desirably flavored feed. The cows refused to eat it while they were eager to eat the hay preserved with the CO₂ and nitrogen.

In 1932 we prepared two barrels of green hay with dry ice. In one five pounds of magnesium sulphate per ton of hay was mixed, and in another barrel five pounds of calcium chloride per ton of hay was mixed. The magnesium sulphate gave a much greener hay, thus showing a better preservation of chlorophyll, while the calcium chloride deteriorated the chlorophyll to a certain extent.

In another barrel a half pound of iron ammonium citrate per ton was used with 56 pounds of dry ice. The iron ammonium citrate apparently darkened the hay but evidently did not deteriorate the chlorophyll. When fed it did not interfere with metabolism, and an extract of this hay decidedly increased the hemoglobin of the blood of a rat. Most of this physiological work was done by Dr. Lowell Erf, then of the Medical Research Department, Ohio State University.

We continued the experiments with dry ice in barrels with higher pressure and with higher temperatures. A few barrels with hay, preserved at the rate of 70 pounds dry ice per ton of hay, were kept at 65 degrees for six months with 15 pounds pressure. Others were filled with the same, using dry ice at the rate of 70 pounds per ton under 15 pounds pressure at 70 degrees. Some were only stored for three months, and in these the hay remained in splendid condition, although there was some degeneration and a little mold in the hay kept six months. Another barrel, mixed at the rate of 80 pounds dry ice to the ton of hay and kept at 80 degrees with 10 pounds pressure for six months, showed deterioration and mold and loss of carotin. Another barrel, having 100 pounds dry ice at 90 degrees temperature for six months, showed marked deterioration and considerable mold.

At Randleigh Farm in 1933 three tanks were filled—one with damp hay dried for four hours; a second with green hay cut and immediately

stored, and a third, with dry hay. Each tank contained a layer of dry ice at the ratio of 280 cubic inches of ice to the 50-gallon tanks. These tanks were stored at a maximum temperature of 78 and a minimum of 62 degrees until May. When they were opened there was no pressure; all were found to be somewhat moldy and sour. The larger amount of dry ice produced a high pressure and opened the joints on the tanks and released the pressure. We apparently had used too much dry ice for the tank.

Next year on the Randleigh Farm, the tanks were refilled, using only fresh cut green and partly dried hay. In one tank the hay was dried in the sun for four hours. Carbon dioxide was again used in the form of dry ice in both barrels, at the rate of two cubic inches per cubic foot of hay. The ice was broken up into small pieces and distributed through the hay as evenly as practical. These were sealed (and put away at temperatures the same as in 1933) until May, 1935. These were in much better condition when opened than those of the previous year. The hay retained its green color and high percentage of moisture without being sour. The hay was palatable to cows. This indicated that small pressure in the tanks is important for hay preservation. We were greatly aided in this experiment by B. A. Lee, engineer, and T. E. Grow, manager of the farm.

We also filled a tank in 1933 on the Raemelton Farm, Mansfield, Ohio, owned by Frank B. Black. The work was done by Otto Kline, manager of the farm. The tank was filled with hay at the rate of 70 pounds of dry ice per ton of hay and stored at ordinary barn temperature for three months. The tank developed a low pressure for a time. The hay was preserved in perfect condition. In 1934, Mr. Kline made the first attempt to fill a glazed tile silo. Thirty pounds of dry ice and 60 pounds of dry molasses were used per ton of hay. We found that sugar deteriorated the chlorophyll and did not hold a sufficient amount of CO₂ to prevent a slight molding. However, a large amount of hay was palatable although it was brown in color. The silo was made of tile and was painted in order to be gas-tight. We discovered, however, that the gas would leak out around the joints.

Our second experimental project on hay on Randleigh Farm was to determine the effect of different percentages of moisture in hays while continuing to use 70 pounds dry ice per ton. One barrel containing hay with 85 percent moisture in the green state and a second barrel with 68 percent moisture, both under a 10-pound pressure, were

stored for five months. We found a marked deterioration in the hay with 85 percent water. The 68 percent hay, after a period of five months, retained its normal green color and was in a good state of preservation. In 1935 also, a silo at Raemelon Farm was filled at the rate of 70 pounds dry ice per ton of 85-percent moisture hay with molasses and without pressure. The hay was markedly deteriorated and was of comparatively little value. A similar silo was filled on the farm of George Gray, Coshocton, Ohio, and we found it, too, to be not a success. With the different experiences we have had in our work, we have come to the conclusion that no silo is really tight enough to preserve hay with gas. It seemed that a slight pressure with a moderate temperature and a moderate percentage of water in the hay were principal factors in preservation of these hays.

Mr. Bookwalter and the William Bayley Company visualized in 1935 the importance of this method of making hay in the autumn, when usually hays are lost; and they made a metal tank with the joints properly packed with rubber, with rubber set-in joints at the door, and with a tight top. They proceeded to fill this tank (which was eight feet in diameter and 28 feet high) with cut alfalfa. The knives on the cutter were set at one-half inch. This silo was filled in three days, using 70 pounds of dry ice per ton of green alfalfa. Due to the fact that it took so long to fill the tank, only two pounds of gas pressure developed. The hay remained in the tank from September 3, 1935, to January 11, 1936, with a maximum temperature for a few days of 80 degrees F. and an average temperature of about 58 degrees for the first 30 days. The temperature after this varied from 58 degrees F. to 10 degrees. This particular tank had no insulation. When opened on January 11, the feed was in perfect condition, with a slight deterioration of chlorophyll but a 50-percent loss in carotin, and was apparently palatable to the cows. This was the first successful practical attempt on a large scale to preserve green autumn grasses as they are brought in from the field.

Bookwalter Experiment, 1936.

The experiment of 1936 at Lynn Guernsey Farm owned by Mr. Bookwalter was similar to that conducted the previous year except that more dry ice and higher pressure were employed, and also in 1935 a pure alfalfa was ensiled while in 1936 a mixture of equal parts alfalfa and soybeans was stored. A large acreage of soybeans is planted in this section of the state, and usually only a part can be saved by

ordinary hay curing processes, due to fall rains. It is seldom one can make soybean hay in late fall and have desirable winter feed. We have no method as here described to save an early summer hay crop, due to the fact it contains more valuable nutrients, as vitamins and minerals, which are easily destroyed and can not be preserved in silos with dry ice alone (without refrigeration) as we have done in the fall. The hay drier is still the best known means to save the most nutrients in hay. There are instances, although rare, when a large amount of a mixture of green timothy and alfalfa, or of clover and timothy, can be preserved for more than 30 to 60 days; but in no case yet have we found hay stored in silos for nine months to be a satisfactory feed.

Last fall (October 3, 1936) on the Bookwalter Farm alfalfa-soybean hay was stored in the air-tight metal silo (8x28 feet). While 600 pounds of dry ice was used the preceding year, 1000 pounds was put into the silo for 22 tons in 1936, or 45 pounds of dry ice (CO₂) per ton of hay. It seems the larger amount of dry ice preserves the original flavor of the hay better than the lower quantity because it keeps the acidity at a lower level and keeps down molds.

The silo was opened January 6, 1937, and the hay quality studied. The hay was well preserved and extremely palatable. Only a third of the carotin was left, according to analyses made by Dr. O. L. Inman, in the first two feet of silage. The original hay contained 5.2 mg. of carotin to 100 gr. of hay. The first two feet contained 0.7 mg.; the middle, 9.5 mg., and the bottom, 10.1 mg. The increase was due to the breaking down of the "green" material, making more available the yellow factors.

We started in 1935 at Randleigh Farm to vacuumize hay, in other words, to draw the excess CO₂ from the green hay. When done in glass belljars at 16 inches of vacuum, the hay kept perfectly at an outside temperature ranging from 40 to 55 degrees F. While such small quantities are not a reliable criterion, since the hay can not be packed as in large drums, W. R. Kenan has devised a system with a vacuum pump, automatically controlled and attached to hay drums, as described by him.

A further test in curing alfalfa hay was carried on during 1935-36 at Randleigh Farm, and this test, along with the one in 1936-37, is described by Mr. Kenan on pages 87 to 89, inclusive.

The tank or receiver used by Mr. Bookwalter costs about 40 per cent more than an average metal silo. If, however, insulation on

the outside is desired, the cost would be slightly more, depending on the kind of insulation. J. W. Persohn, engineer of the National Carbide Company, has been a great aid to us in our dry ice problems, especially those concerned with circulation of gas in the tank.

Approximately 74 percent of ordinary hay is changed to a gray-brown color in curing, and about 11 percent can only be used for bedding. There is no hay made at present, as far as we know, that is equal in nutrition to this green, natural hay as it is preserved by dry ice in these hay tanks even though some of the carotin is lost at the top of the receiver. A saving is effected over that of mechanically and artificially dried hays, from the nutritional standpoint, regardless of the loss of some carotin. The silage at the bottom had retained its full carotin content.

The advantage of artificially dried hay is that it can be shipped and merchandized while green hay preserved in tanks is only practical when used on the farm upon which the tanks are located or where it can be delivered short distances in a short time to prevent deterioration. The advantages that are attained are difficult to estimate either way. The dry ice costs from \$1.75 to \$2.25 per ton of hay, which is slightly more than the cost of windrowing together with the loss of leaves during the usual drying processes. The extra hauling and cutting also costs a trifle more than does storing in the barn with a hay fork, but we find it preferable to handle the cut hay. Cut hay is also much easier to feed and Miller's disease, which sometimes develops in cows due to dusty hay, is completely eliminated.

We believe that, taking everything into consideration, the advantages of this system of storing green feed are so great in comparison with the ordinary system of fall hay making that we can eliminate the factor of increased cost.

While we are enthusiastic about this method of hay making, it must be understood that further improvements must be made to preserve a larger percentage of nutrients. In the development of any new method only time with constant thought and improvement will make the process so practical that it will be acceptable to the general public.

CHAPTER XXX.

DEFINITIONS AND TERMS

Carotin Needs

WE HAVE found that hays containing 18 mg. of carotin per 100 grams of hay will produce hatchable eggs, if the hay is fed to the breeding flock at the rate of five percent of hay meal in the feed ration. This is on the assumption that about 65 percent of the eggs hatch under good conditions, taking all variable factors into consideration. Also, some other vitamins, the effects of which are not yet fully determined, as, for instance, vitamin G, probably have some influence on hatchability. Our experience though has indicated that this amount, more or less, will be needed.

This same condition may be true in calf production. We have found that with 12 mg. of carotin per 100 grams of hay at least 10 pounds must be fed daily to produce a good calf from good producing cows; and furthermore, hay with 4.5 mg. per 100 grams and fed at the rate of 10 pounds daily does not produce a strong, healthy calf that will develop into a cow of satisfactory production under average conditions.

Hormones

A pro-vitamin is a precursor of vitamins. Carotin is spoken of as pro-vitamin A. Ergosterol is pro-vitamin D.

Hormones, as described in this text, are chemical substances produced in one organ (particularly by endocrin glands) and transferred by the blood stream to an associated organ in which there is exerted a functional activity. They differ from vitamins which are considered essential constituents to the normal functioning of the body and must be ingested by the animal.

There are many hormones in the body but comparatively little is known about them. Some of the most important ones are produced in the anterior pituitary located at the base of the brain, and are concerned with reproduction and growth. Insulin, a secretion of the pancreas, is commonly used in the treatment for diabetes, reducing blood and urine sugar to normal and also reducing acetone bodies in urine. Hunger hormones, metabolism hormones and sex hormones are mentioned.

Thyroxin may be an extract from the thyroid gland or a synthetic compound which possesses the physiological properties of the normal

gland. It is used in defective thyroid functioning as in single goiter, and cretinism, which affects persons of mature age. It also influences lactation. The administration of thyroxin increases both the milk yield and the quality of milk, particularly with cows in declining lactation. Milk secretion is governed by three hormones. The stimulus for the growth of the mammary gland, which takes place before secretion, is dependent on two of the hormones produced by the ovary which are known as theelin and corporin. Theelin develops the udder in the early stages while corporin later prepares the udder for milk secretion and also causes the enlargement of the gland. The beginning of secretion is due to a third hormone, "galactin," secreted by the anterior lobe of the pituitary gland. This hormone is liberated into the blood stream after parturition, and on its maintenance depends the milk yield. Some influence must also be attributed to the preparatory hormones of the ovaries.

STANDARD UNITS FOR EXPRESSING CURATIVE OR PREVENTIVE AMOUNTS OF AN ACCESSORY FOOD SUBSTANCE

O. L. INMAN

Biological assays have not been uniformly conducted and even yet are not well standardized. One of the usual procedures in making a biological test of vitamin A is to take albino rats (from 25 to 29 days old, and from 35 to 45 grams in weight) of the same litter and sex, if possible, and keep them on a standard-free vitamin A-free diet until there is a stationary or declining weight for about a week. Definite amounts of cod liver oil are then fed daily to these rats. The vitamin A strength of the oil is expressed in units per gram of oil, the unit to be a maximum daily amount of cod liver oil required to cure induced symptoms of vitamin A starvation in young albino rats, and to cause a gain in weight of from 10 to 20 grams within a period of 35 days. Each test is to have two or more controls with the basal diet given. ("The Vitamins," L. B. Mendel and others. Mead Johnson & Co., 1932.)

Many experiments now use as the unit one gamma or 0.001 mg. of pure carotin as the equivalent to one International Vitamin A Unit (I. U.). This has advantages since carotin can be obtained in pure crystalline form and standards can be better prepared. The need for clarification still exists since pure carotin is not always defined as to whether it is the alpha, beta or gamma form, and they are not equally transformed into vitamin A in the animal body. The most commonly

accepted standard today is in terms of beta carotin since it is the most abundant form found in green feeds and is readily transformed into vitamin A in the animal body.

In the case of vitamin A the pure compound has not been available to the experimenter and it has not been easy to establish a better standard than that based on pure beta carotin. The analysis of the carotin content of green feed in either the fresh or stored state is most often expressed in milligrams of carotin per 100 grams of dried feed. From these data one can then calculate the amount of carotin available for conversion to vitamin A provided the carotin is considered to be mostly in beta form. This avoids expressing vitamin A in such a term as "blue unit," which is not satisfactory from many points of view.

CHAPTER XXXI.

HISTORY OF THE MILK BUSINESS IN RELATION TO
HUMAN HEALTH

ORIGINALLY the dairy business was largely concerned with furnishing a food product with comparatively little regard as to price. However, as time went on, the original policies began to differ from those of individualism and independence to monopolism. The original idea of producing a food which gave health and strength to mankind was lost sight of, and the question of commercialism superseded. This problem came about largely through the gradual differentiation of the business.

History of Feed Business

The purchase of feed for dairy cows is a markedly different policy today than in the past. Milling processes, factory operations, by-products, labor, etc., have all altered the policies of former days.

Formerly the cow received her feed largely from the woodland pastures and the gleanings after cropping. The large variety of grasses available and their abundance naturally supplied a milk that was extraordinarily rich in nutrition. The milk delivery system in those days, except in a few instances in the large eastern cities, consisted of having the customer come to the place where the cow was kept. In the winter months it became necessary to provide more cows. Sometimes the price for milk did exceed three or four cents a quart. Later as the milk had to be delivered it was considered reasonable when priced at about five cents a quart.

No thought was given to testing cattle as to whether they were healthy. No provisions were made as to sanitation. During the summer the cows were milked in the pasture fields into buckets which were sterilized by the sun. During the winter whenever the demand became sufficient the cow was supplied with feed, consisting largely of straw and cornstalks when available; and oftentimes she was fed ear-corn and oats. The cow was often milked around the straw stack, and this frequently became an insanitary place.

As spring approached these cows gave poor quality milk due to poor feeding. In some instances hay was fed in the late winter when corn and straw were not available. This hay was usually stacked in the field and the cow was allowed to feed around it. The good hay, however, was produced largely for horses and was not intended for

the cows. In other words, the cow in former years ate what was available in the pasture field and usually utilized the refuse of the hays and other winter feeds. Naturally, the greater part of the year good milk was produced because the cow had to browse for existence; and when there was much pasture available, milk was abundant.

As population increased and as more land was farmed the demand for milk began to increase, and the whole problem changed. The area of land for pasturing was greatly reduced. More highly specialized milk cows were provided. Formerly the cow was largely a beef animal, the calf furnished veal, and the steers, old cows and bulls furnished beef. This system produced sufficient milk for home or community consumption. This method of dairying still furnishes 60 to 70 percent of the butter consumed in the United States. The quantity of milk produced per cow was rather small, but due to the fairly abundant feed the quality was kept up.

However, the highly specialized cow introduced later had to be fed better. It became necessary to supply hay for these cattle along with corn and oats. With the advent of the clover plant cows began to receive more proteins, which somewhat improved the milk during the winter months. In the East where large cities began to develop, milk was hauled to market in wood-stoppered cans or sometimes in wooden firkins, from which it was dipped into the customer's receiver. It was not until 1830 that milk was transported by train to Boston and New York, and the neighboring farms then supplied the milk. Barns and sheds were constructed, and dairying for the sale of milk became an extensive business. Refuse from the breweries and distilleries provided the grain feed near the cities. This had formerly been used to feed steers owned often by the distilling companies. Cattle fed this refuse produced milk but seldom calved over a long period of feeding. Hence these animals were fattened for slaughter as their production went down. The highly specialized animal which gave more milk produced comparatively little meat and in many instances had to be taken back onto the pasture in order that reproduction might be brought about. Only in a few cases where bran was fed in large quantities were the reproductive properties maintained by keeping the cows in stables and feeding them the year around.

Sanitation Neglected

These stables became insanitary as time went on, for usually cattle were collected more for beef than for milk production. Naturally a

large number of cows were collected which the farmer did not want and which we understand now were diseased. Besides being milked in a filthy stable in a filthy manner, milk was poured into a receiver brought to the dairy stable by customers, and the rest was put into cans and distributed into smaller receptacles provided by the city consumer. Morning milk was quite often sour by night, and therefore it was necessary to distribute milk twice a day. During the summer cholera infantum and cholera morbis prevailed; and while the nutritive value of the milk was low, the heavy infection made it still poorer as a food product. Milk was largely used for cooking purposes and only children drank it, and then it was often boiled for them.

These insanitary conditions became so serious that by 1898 cities began to protect themselves by setting up rules and regulations as to inspection and providing inspectors to enforce these sanitary laws. Previously as cities in the East began to grow, dealers who ran short of milk in their own little routes bought milk from other people. It was not with the intention of commercializing the milk business but to supply the demand of the people, since the dealer himself had neither room nor ability to care for a sufficient number of cows. Milk in those days oftentimes was sold for 40c cwt. and was rarely more than 80c cwt.

Milk Dealers Arise

Gradually it was discovered by some individuals that this was an opportunity to commercialize the business and establish themselves in the milk industry, usually in barns or kitchens in the city. This so-called "milk dealer" would then drive out and buy so-called surplus milk from different farmers, which was produced under all kinds of conditions, often with no thought of producing a sanitary product. Milk might be gathered from families infected with tuberculosis, typhoid fever, scarlet fever, diphtheria and other diseases.

While the dealer did not intentionally become a spreader of disease, he did, however, commercialize the business and dispensed the fluid without any regard for health or nutrition. It became somewhat difficult to raise children in the city. Only breast-fed children and those which afterward were fed on boiled milk were protected. If the mother would supply vegetables, fruits and the like, the child was fortunate enough to grow to full maturity without having the terrible prevailing children's diseases.

This system remained for many years and nothing was done to improve it until Dr. Coit of New York City recognized the severity of

the situation and prevailed upon a Mr. Francisco, dairyman of Montclair, N. J., to produce milk from healthy cows that was clean and put into clean bottles. This was known as certified milk. This milk was a blessing to society, and it looked for a while as though people would readily purchase this kind of milk and dairymen would adopt this plan.

It was an unfortunate moment, however, when the producing end and the distributing end of the business were divorced. The latter is, of course, the more profitable. As a consequence, the so-called buyer or distributor of milk began to press out farther into the country to buy surplus milk and then gradually contacted producers in areas remote from the city. Naturally certified milk could not compete in price, and gradually the nutritive value of milk was disregarded in favor of price.

Children reared on this type of milk were lacking in protective substances and consequently were at the mercy of all sorts of prevailing diseases. As cities grew larger, the distributors naturally became bigger, and they developed milk plants for processing, which had formerly been done in city kitchens or stables. These plants were built on a more sanitary scale and stock companies were formed.

Naturally the price to producers was gradually crushed down, and the breach between consumer and producer was widened. The producer with such low income could not operate with any degree of sanitation. He could not afford to buy feeds necessary to make milk more nutritious, wholesome and sanitary.

Cooperation Deemed Necessary

It was at this time that farmers began to organize to defend themselves. The problem became complex for demanding a raise in the price of milk and was not always fair because the dealer was also meeting marketing obstacles. Early in the organization period, the author attempted to analyze the situation and began organizing the producers on the following principles:

(1) To prevent adulteration and misrepresentation, for at the time oleomargarine was sold for butter and other oils were mixed with butterfat. A starch skim-milk oil mixture was masquerading as condensed milk. This had a decided influence upon market conditions.

(2) To protect our markets against foreign imports from countries where the standard of living was lower than ours. This could easily be done by raising the tariffs.

(3) To demand that all cattle be tested by the state and federal governments and that disease-free areas be maintained. The cows should be tested for tuberculosis, Bang's disease or *B. abortus*, mastitis and streptococcic infections in the udder.

(4) That all non-profitable cows be eliminated from the herds by cow-testing associations or official testing.

(5) By demanding uniform enforcement of proper standards of sanitation and regulation, demanding that milk only be brought into the market from inspected areas.

(6) That areas be selected according to the degree of sanitation maintained.

(7) That milk be purchased only from cows that have been properly fed in order to maintain the nutritive qualities of the milk.

(8) That milk be sold by cooperative bargaining methods by which a price is arrived at by mutual agreement of the producer, distributor and consumer; or, what is deemed preferable, producers shall collect, pasteurize and bottle their own milk collectively and sell it to the distributor; or still better, they shall maintain their own collecting and manufacturing plant for the purpose of taking care of their own by-products, and to distribute their own products. This is similar to what is known as the "Cincinnati Plan" which has been operating successfully for 10 years or more.

The idea of the last two plans was to bring back the original system in a modified form in which the milk was produced and distributed by the individual. It must be said, however, that such cooperative plants can not operate by themselves, and that ingenuity and ability in a plant manager are necessary. Cooperative plants can not operate efficiently without good managers.

By cooperation manipulations of stock are prevented, which usually has a tendency to treat the nutritious value of milk as a matter of minor importance and makes stock gambling the important part of the milk business. It is quite necessary that these two problems be kept properly balanced at all times. This has been found difficult to accomplish, especially in privately owned distributing plants.

Pasteurization is Adopted

To safeguard the public it was found that inspection was not sufficient protection, and consequently pasteurization became necessary. This increased the prestige of the distributor. Pasteurization was

heralded as a method that would make milk perfect regardless of the carelessness and filthy habits practiced by the producing dairyman. It is true that pasteurization has considerable merit—in fact, heating milk to 142 degrees for 30 minutes does destroy such organisms as typhoid, diphtheria, scarlet fever and tuberculosis in its vegetative stage, but it may not destroy the highly resistant germs, such as some of the streptococci and anthrax. We feel that pasteurization performs only a partial job in respect to sanitation.

The most serious thing is the fact that, due to poor feeding of cattle, deficiency diseases are created, and naturally milk produced from such abnormal cattle causes similar diseases in the human being consuming such milk.

We are told all this can be remedied in pasteurized milk by addition of vitamins, pro-hormones and minerals, and that in some instances distributors have done so, claiming a product superior to raw milk. Fortunately laws in various states do not permit addition of these materials. If they are to be added to the human diet, this should be left only to competent physicians who are able to diagnose the deficiencies and prescribe accordingly. Such a complex and intricate process should never be left in the hands of a layman who does not understand. These constituents added to milk, as has been repeatedly demonstrated, do not provide for as good nutrition as that which comes from milk of cows that have been properly fed. It must be recognized that deficiency diseases are as dangerous and cause death just as regularly as do bacterial diseases.

The great pioneer work of Dr. Ernest Scott, which was fundamental and naturally criticized, was the beginning of the change in sentiment in the milk business by the distributor. We are quoting the early work of Dr. Scott and his staff as follows:

EFFECTS OF CATTLE FEEDING AND
PASTEURIZATION ON THE FOOD VALUE OF MILK*

ERNEST SCOTT, M.D.

Dept. of Pathology, The Ohio State University
and

L. A. ERF, M.D.

White Cross Hospital, Columbus, O.

In a previous report the results of experiments were presented which tended to prove that the nutritive value of milk is influenced by the ingredients of the food eaten by the cow, that the milk of cows upon a proper diet does not produce anemia in the rat, and that the heating of milk tends to lessen both its growth promoting and hematogenic properties.

The belief that milk is not a complete food and that its exclusive use brings about a lack of growth and vigor in the young, and that the hemoglobin and red corpuscles of the blood do not develop in a normal manner is being widely accepted. This opinion rests largely upon the work of Steenbock and Hart, who some years ago found that young rats fed an exclusive milk diet developed an anemia. This fact created great interest in the subject of "nutritional anemia" and has stimulated an active reconsideration of the entire subject of milk as a nutritive substance. The degree of interest created in these subjects is attested to by the ever increasing number of reports of experimental work done in this field. A brief review of Chemical Abstracts, the Journal of Biological Chemistry, the Journal of Nutrition, Archives of Pediatrics, various health, dairy or home magazines will convince one of the public as well as the scientific interest in the subject.

In our experiments above referred to weanling albino rats were used whose mothers had received only milk as a diet during their nursing period; the young were weaned upon an entire milk diet, none of the experimental animals having tasted food other than milk. The cages in which the animals were housed were constructed of galvanized wire mesh, special care being taken that no iron or copper was exposed. The food containers consisted of glass jars of suitable shape. The preliminary tests consisted of the feeding of a group of six rats upon milk obtained from a well-fed Jersey herd. Repeated examination of the blood and frequent weighings of these animals over a period of several months failed to indicate either the development of anemia or any retardation in growth. After seeking some advice as to our difficulty it was decided to repeat the experiment. With the second group of animals, however, market milk was used because of the greater ease with which it could be obtained.

*From Proceed., Int. Asso. Dairy & Milk Inspectors, 1931.

The animals of this group soon indicated by appearance, weight and blood count, that they were not developing as the animals of the first group had done. It was then determined that these experiments should be repeated and extended to include a comparison of several types or grades of milk; these grades being (1) certified milk, four percent unheated, (2) the milk from cows fed upon a special feed mixture, 4.4 to 5 percent unheated, (3) the commercial market milk, 3.8 to 4 percent, heated, pasteurized. The herd from which the certified milk was obtained was at the time of the experiment receiving a warm diet of ground first grade alfalfa hay and grain which were hydrolized and predigested, to which a complex mineral mixture consisting of bone-meal, blood meal, copper sulphate, manganese iodide, iron sulphate, arsenic, aluminum chloride, zinc chloride, silicates and dulse were added. The special milk came from a Jersey herd receiving a liberal dry grain ration plus an abundant supply of first grade alfalfa hay and the mineral mixture as above with the addition of dry fish meal (liver and viscera). The third source was commercial pasteurized milk obtained from a market in the vicinity of the laboratory. The diet of the cows producing this milk was entirely unknown, but may be assumed to be that of the average dairy cow. All the special feeding in the herds from which the first two milks were obtained was done under the supervision of Professor Oscar Erf, professor of dairying at the Ohio State University.

These experiments extended over a period of five months, and as the time advanced, it became more and more evident that the various groups of animals were not developing equally. The control group, those being fed upon the certified milk, and those fed upon the milk of the cows receiving the special feed were all in good condition with sleek coats, clear eyes, playful, and of gentle disposition, while those fed upon the market milk were dull, listless, irritable, with rough coats and dull eyes. The weight curves and the blood counts also showed variations. At the end of the five months

The control group showed an average gain of 55 grams.

The certified group showed an average gain of 57 grams.

The special group showed an average gain of 88 grams.

The market group showed an average gain of 33 grams.

The red cell count at the end of the same period was:

The control group—an average gain of 3,200,000.

The certified group—an average gain of 2,700,000.

The special group—an average gain of 2,000,000.

The market group—an average loss of 1,700,000.

The experiment was repeated upon three other series of rats and in each experiment these results were duplicated to a surprising degree. During each of the tests it was noted that the rats receiving the market milk consumed more milk per rat per day than those receiving the

special milk or certified milk, and yet as indicated, their growth was retarded and they became very anemic. In one experiment a group of six young rats averaging 20 grams in weight and with an average red cell count of 5,500,000 was placed upon the special milk diet for a period of 98 days. At the end of this time the average weight was 110 grams and the red blood count 9,700,000. They were then placed upon the heated market milk for 124 days. During this entire period the weight increase was but 15 grams, and the red blood count indicated a loss of 5,900,000 cells. These same rats were again placed upon the diet of special milk for a period of 90 days during which there was an average weight increase of 57 grams and a regeneration of red blood cells until the normal count of 9,600,000 was again reached. These rats were again given a diet of pasteurized market milk for 37 days. At the end of this time the group had lost an average of 37 grams in weight, and the red blood count indicated a loss of 5,800,000 cells. Thus by varying the diet from the special to the pasteurized market milk it was possible to repeatedly retard or accelerate the weight and to increase or decrease the red blood count to a marked degree.

Further experiments were also reported in which two portions of the same sample of the milk of the cows on the special diet were used, one portion being heated to 62 degrees C. for 30 minutes, the other being used unheated. The results of this test indicated a loss of 21 grams in weight and six percent in hemoglobin, with a decrease of 1,200,000 red blood cells in those fed the heated fraction. This portion, however, showed a gain of 95 grams in weight, 3,300,000 red blood cells and 30 percent hemoglobin over the group fed upon the commercial heated milk.

A further experiment indicated that the addition of cod liver oil and tomato juice to the diet of commercial pasteurized milk did not increase its nutritive value sufficiently to equal that of the milk from the cows upon the special feed. In this test the animals upon the special milk gained 122 grams, those upon the commercial pasteurized gained 54 grams, and those fed the commercial pasteurized plus cod liver oil and tomato juice showed an average gain of 78 grams.

Since the completion of these series of experiments the authors have reviewed the literature of the subject somewhat and have been able to find numerous reports of experimental work done which seemed to bear an interesting relationship to the work here presented.

One of the most recent and striking of these is the result of the work of Thomas MacLeod and of Krauss and Bethke, who have proved that the anti-rachitic vitamin D is greatly increased in the milk of cows fed upon irradiated yeast or irradiated ergosterol. Thomas and MacLeod find that vitamin D can be increased in the milk as much as 16 times in this manner. Hess and his co-workers have utilized this fact clinically and report many advantages in both the prevention

and the treatment of rachitis by the feeding of "anti-rachitic cow's milk," stating that when rachitic infants were fed upon such milk definite calcification was brought about within 30 days.

Roessler in experimenting along similar lines found that "the milk of cows on a green fodder diet had the same effect as ergosterol, but that winter milk did not possess this property."

Hunt and Krauss have proved that the milk from cows on green pasture has a higher vitamin G content than cows on dry feed, and that cows on pasture during a vigorous plant growth produce milk with a higher vitamin G content than those on pasture that is over-mature. These authors also state that vitamin B is influenced in the same manner but to a less degree. Ernst states that both quality and quantity of milk are dependent upon the quality of the cow's food, and also that the texture and quality of butter is determined by the diet of the animal. Brown and Sutton have proved that the administration of Menhaden (fish) oil to producing cows not only "lowers production, but also the percentage of butterfat and the total amount of butterfat."

Daniels found that vitamins are present in the milk only in the proportions existing in the diet of the animals producing it, and further that "milk sterilized by the now existing methods can not now be relied upon to supply the anti-scorbutic vitamin C." Osburn and Mendel and Steenbock, Sell and Buell have proved that milk heated in the open air loses vitamins A, B and D. Daniels and Loughlin, comparing rats fed slowly pasteurized milk and that rapidly boiled, state "those fed the slowly heated milk grew slowly, reached only one-half normal size, and failed to reproduce. Those fed the quickly heated milk grew normally and to all appearances were perfectly nourished animals."

Ladd, Evarts and Frank in an extensive feeding experiment with young children showed that certified milk was superior in nutritive qualities to either Grade A pasteurized or Grade A pasteurized plus cod liver oil and orange juice. They indicate the difference may be due to the more exact and scientific feeding of the cattle.

Catiff and Pollaske have proved that normal young goats fed exclusively upon autoclaved cow's milk suffered a complete retardation of growth within a few days in eight of ten experimental animals.

Daniels and Stussey have shown that rats fed boiled milk grew to one-half their normal size and did not reproduce, while Mattak and Golding were able to show marked variation in growth and weight curves between rats fed upon milk after heating at various temperatures. They also observed marked changes in reproduction in those rats fed upon diets of raw, pasteurized and boiled milk, the rats upon the raw milk producing 41 living young representing 524 nursing days, those upon pasteurized milk had 22 living young who had 169 nursing days, while those on boiled milk failed to reproduce entirely.

That this apparent deleterious action of heat is not confined to milk is indicated by the report of Freidberger, who found that animals fed

raw foods eat only one-third as much as do those fed the same feeds cooked, and also that the animals subsisting upon raw food gain about twice as fast as do animals fed cooked food alone. The addition of vitamins to the cooked food did not change the biological effect of the food mixture. The same author found that rats fed raw eggs gained 140 grams in weight in 2.5 months, while their litter mates gained only 88 grams in the same time on boiled eggs.

Morgan and King observed decided retardation in growth as the result of feeding cooked cereals. An editorial appearing in the *Journal of the American Medical Association* for January, 1931, states that "relatively long heating even at a moderate temperature in open utensils tends to decrease the content of all known vitamins, notably at neutral or alkaline reaction. Likewise, inorganic salts tend to be leached from material being cooked and with vegetables are frequently entirely discarded." Richardson writes, "The value of raw milk can not be over-estimated in the diet of pregnant or nursing mothers, as it is a great source of vitamin essential to growth and development of children."

Lachet indicates the growing belief among investigators that carotin, the yellow coloring material of plants, is definitely correlated with the physiological activity of the fat-soluble vitamin A. Hart states that we now know or think we know that carotin is the precursor of vitamin A and "that vitamin A is more abundant in the milk of pasture fed cows than those stall fed." This is of interest in the present connection because of the fact that carotin in association with chlorophyll is the pigment which gives the characteristic green color to the grass and to leaves of trees and plants. Chemists inform us that chlorophyll of green grass and vegetables is almost identical in chemical composition with the hemoglobin of the blood, apparently performing the same function in the plant as does the hemoglobin in the animal body. As has already been indicated, it is the actively growing green grass and the hay that maintains its green color, that gives the high vitamin potency to milk.

A further interesting observation along this same line is that of Koessler and Maurer, who assert that vitamin A is essential for normal blood regeneration, and that there is a definite relationship between a state of chronic vitamin A deficiency and certain anemias of man.

This brief survey of the work being attempted in this field indicates the trend of the thought that is stimulating the research now being carried on in an endeavor to solve some of the many unknowns in the problem of milk in its relation to nutrition.

In a subsequent series of experiments in our laboratory since the former report, the animals used were again weanling rats who had never tasted food except their mothers' milk. They were housed and cared for as the animals of the first series. These rats were divided into groups of six each. The first group was the control receiving a

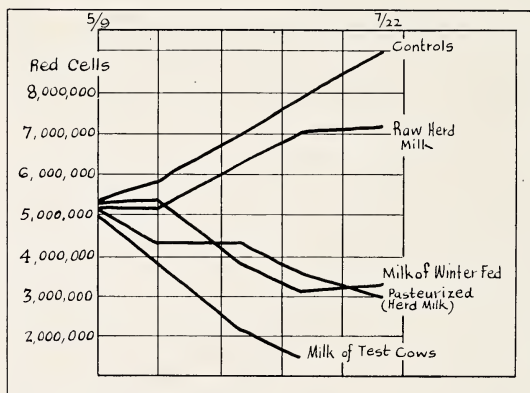
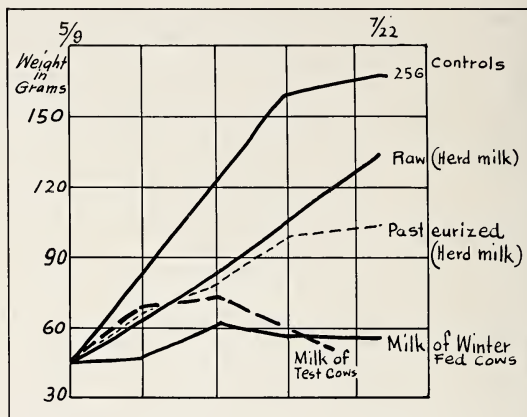
normal diet of grain, vegetables and bread. The second group received the mixed herd milk unheated, the third group was fed the same milk after it had been heated to 145 degrees for 30 minutes. A fourth group of rats was fed upon the milk obtained from cows fed dry winter feed with no grass or other green food during the time of the experiment. The fifth group of animals in this series was given the milk of cows who were upon official test and who were producing from 90 to 100 lbs. a day during the period of observation. This experiment has been of comparatively brief duration, extending over a period of only 11 weeks to date; and yet in this short time rather striking results have been obtained. The experimental animals were all born within a period of three days, and all closely approximated 42.5 grams in weight and a blood count of 5,300,000 red corpuscles when weaned. During the period of the experiment the following results were noted: The control group gained 113 grams in weight and 4,700,000 red blood cells. The group upon unheated herd milk gained 100 grams in weight and 2,340,000 red blood cells. The group receiving the herd milk pasteurized gained 66.5 grams and lost 2,300,000 red blood cells. The group fed upon milk from cows on winter feed gained 12 grams in weight and lost 2,480,000 red blood cells, while those fed milk of cows upon official test gained 9.5 grams in weight and lost 3,601,000 red blood cells.

The herd from which the milk used in this series of experiments was obtained was a Holstein herd that was being fed a warm hydrolized ground alfalfa hay and grain diet similar to that used in the series of experiments previously reported. The mineral ration, however, was omitted as was the ration of fish meal. The cows upon winter feed received a dry grain ration of corn, oats, oil and cottonseed meal with a poor quality of hay (timothy and clover) and a small amount of silage. The cows upon official test were fed the warm ground feed as was the general herd but were fed to their capacity. The animals fed upon milk from these test cows showed early lack of growth and vitality and at the end of six weeks three of the group died. Shortly after this a fourth died, and the remaining rats were placed upon a diet of unheated herd milk with lettuce. One of these rats died within a few days. The other, however, began soon to show increasing activity and in 30 days it had gained 52 grams in weight and the red blood cells had increased from 1,500,000 to 6,300,000.

On discussing these results with the herdsman, he remarked that it only confirmed the fact that experience has taught the breeder, namely, that the calf of a high-producing cow does not thrive on its mother's milk but remains weak and lifeless. Such calves when placed upon milk from cows of lower production soon develop normally.

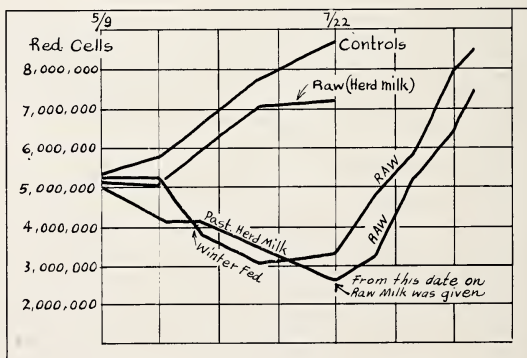
At the conclusion of this experiment the rats of groups three, four and five, or those which had received the heated herd milk, the milk of the cows upon the winter feed, and the rat that had been rendered

Average gain in weight of groups of rats fed exclusively upon different grades of milk.



Average variation in the red cell count made by the same rats as shown above.

This shows the rapid increase in red blood corpuscles following the change to the diet of milk. Rats on pasteurized milk gained 4,900,000 and those formerly on milk of winter fed cows gained 5,100,000 red blood cells in a 40-day period.



anemic by the use of the milk from the high-producing cows, were removed to another laboratory and placed upon a diet consisting of the unheated milk from a Jersey herd that was receiving a liberal dry grain ration plus minerals and fish meal, supplemented by an abundant bluegrass pasture. These animals showed a quick response to the changed diet and within a thirty-day period showed the following gains: The group previously on pasteurized milk gained in weight an average of 51 grams and showed an increase of 5,000,000 red blood cells. Those formerly fed on milk from winter fed cows made an average gain of 63 grams and an increase in red blood cells of 5,500,000. The rat from the group fed upon the milk of the test cattle gained 108 grams and 6,700,000 red blood cells in 71 days upon a diet of raw milk, with lettuce occasionally during the first 30 days.

In still another series of rats which are at present under observation two grades of milk are being used, one the unheated milk of Jersey herd fed upon the diet just described, the other the commercial pasteurized milk as delivered at the laboratory. Each of these samples of milk is divided into three portions, the first portion of each sample is fed as received. The second portion of each sample is heated to 145 degrees F. for 30 minutes (pasteurized). The third portion is boiled for 10 minutes. The rats used in this series were all born within a period of 48 hours and were placed upon the test diets somewhat earlier than those of the preceding series, the average weight being 20 grams and the red blood count 5,500,000 and hemoglobin percent of 90 plus. At the end of the first month these groups are showing decided differences as indicated by their general appearance, activity, weight, blood count, and hemoglobin.

In the experiments outlined 230 animals have been used and the observations have continued over a period of approximately three years. Some of the work has been repeated a sufficient number of times, with entirely consistent results, to have become quite convincing. Other observations, those using the milk from the test cattle and those using the boiled milk, are as yet less certain in our experience.

Although the question of reproduction was not a part of the experiment, it has been observed that in no instance has there been a litter of young born from animals receiving heated milk, while in the series of 1929 there were 23 rats in five litters born from the animals receiving the various types of raw milk.

CONCLUSIONS

1. The results of these experiments indicate that milk is subject to a wide variation in its food value.

2. This variation depends primarily upon the diet of the cow and secondarily upon the procedures to which the milk is subjected before its consumption.

3. The milk from properly fed cattle is apparently a complete food, and when taken exclusively brings about normal growth and a normal blood picture in the albino rat.

4. Experiments seem to prove that the application of heat to milk (or other foods) causes a decrease in the nutritive value, as indicated by the growth curve, the red blood cell count and hemoglobin percent of the albino rat.

In closing we quote from an editorial in the *American Journal of Public Health*, 18:634, 1928, as follows: "Milk varies with the season and the feeding of the cows especially in regard to vitamin content. The public deserves the right to know that there is a great difference between the milk of pasture fed cattle and that obtained from the winter stall fed animals unless especial care is taken to provide a diet sufficiently high in vitamin and mineral content."

Safe Clean Milk

This fundamental treatise will eventually be recognized as the basic work explaining the necessity of good feeding as primary to the prevention of deficiency diseases. These investigators had the courage to publish this work at a time when the health problem in relation to the milk business was considered of least importance.

Milk for children should come only from cows that are repeatedly tested and under constant supervision as to their health and the feed they receive. The new milking plants, such as that developed at Randleigh Farm, makes milking quite safe, when milk flows directly into the bottle from the cow's teat without coming in contact with air. This prevents oxidation, which is so important in preventing changes in the mineral salts of the milk and the proteins and likewise important in retaining the entire vitamin content of the milk.

This milk should not be manipulated in any way except cooled in the bottle and should be consumed within 48 hours from the time it is produced. Regardless of how milk is produced, as soon as it leaves the udder, there are constant changes taking place. The enzymes with their slow catalytic action are sensitive to temperatures and are inhibited by cold. Low temperatures slow up the growth of bacteria. However, moderately low temperatures do not materially check the slow but gradual changes in milk. Milk, even though produced under the best sanitary conditions and kept at low temperature, will become somewhat unpalatable in 60 hours after it is produced, especially when it comes from cows fed with a feed of a low percentage of "green" or

if the feed contains non-oxidizable material. This unpalatable flavor can usually be overcome by feeding green grass or fresh germinated grain and dehydrated hays. In fact, dehydrated hays are a factor in improving the flavor of milk.

The common concept that as long as milk is sweet it is healthful should be regarded as an untrue statement. It is true that some milk can be kept longer than other, depending upon the cow and the character of feed that she consumes. Take, for instance, the effect of vitamin C upon the flavor of milk. Cows fed large quantities of vitamin C, such as found in sprouted grain, give milk with a clean palatable flavor, especially if the milk is milked directly into the bottle.

It has long been known that green grass and sprouted grain fed to cows do decidedly improve the flavor of milk. This is due to the highly oxidizing nutrients and volatile essentials. Such milk, therefore, should be consumed within a definite time, and if older should not be sold as a raw or natural, wholesome milk but as cooking milk. This then would naturally put milk into two classes:

- (1) Milk for children, invalids and table use, which is produced clean and raw.
- (2) Ordinary milk which can be produced if necessary in large areas away from the point of consumption.

CHAPTER XXXII.

SANITATION AND FEEDS VERSUS PASTEURIZATION

IT HAS not been many years ago that Pasteur discovered a method of heating to regulate the infections of grape juice in order to permit the normal fermentation of wines. This same principle was applied to milk. At first it was used primarily to prevent souring. The question of the destruction of disease germs was a secondary consideration, but as time went on we began to recognize the importance of pasteurization from that standpoint. The author began some experimental work more than 30 years ago to determine the practicability of this method of handling milk. It was his privilege to assist in building the first pasteurizing plant in Chicago under the grant of Nathan Strauss.

Raw milk at that time was dangerous, due to the fact that there were no restrictions or regulations and no one seemed to be interested in protection of the milk supply. Pasteurization was then considered impractical by the distributors and producers, just as the production of natural milk is today.

The heating of milk, which largely killed the lactic acid bacteria but left the highly heat-resistant bacteria, was found to be a sales advantage. As time went on small pasteurizing or heating vats were put into dairies to save the milk from souring in hot weather. More and more distributing plants began to develop, using the so-called pasteurizing operation.

Food Value Reduced by Pasteurization

Recognizing its value from a scientific standpoint as it was formerly presented, we began to pasteurize milk for calves on many farms to overcome some infection difficulties, for on some farms calves could hardly be raised. We discovered that pasteurization gave us little relief. Where calves are kept in sanitary conditions they grow better on raw milk than on pasteurized, and as John Beidler, a prominent dairyman, stated the case years ago, this whole question is more a problem of cleanliness than pasteurization. He told me at the time that he felt our pasteurizing system was of comparatively little value, in his judgment.

Medical science likewise began to show the value of clean, sterile conditions; and instead of operating where conditions could not be

controlled it was advocated that operations be conducted only in a room where the apparatus, walls, floors and air can be made clean and sterile.

Many physicians then did not concur in the opinion that heating milk to 142 degrees for 30 minutes made it safe, and they demanded a higher temperature with a longer time of heat exposure. This demand was greeted resentfully by the commercial interests because more heating destroyed the cream line and interfered with the sale of the product. Most housewives buy milk according to the depth of the cream line in the bottle. Even though this is a disadvantage we gradually discovered that the medical men were right in their contention. Then gradually some of the child specialists began to complain about the general milk supply, informing us that milk did not nourish properly and that there was something wrong in the production and processing of milk. Dr. Ernest Scott, who was in close contact with pediatricians and who had autopsied thousands of bodies, finally came to a similar conclusion and to convince himself, inaugurated a series of experiments which showed that the abnormal results that pediatricians were observing were not due entirely to heating milk but were also due to poor nutrition to the cow.

There were many disadvantages in getting a normal, wholesome milk supply from a large group of scattered farm dairies on which there existed numerous infections and where many of the cows were diseased. Men also were careless in handling the milk and the men themselves were sometimes diseased. All milk of this kind was brought into a city distributing point and poured into a vat and there heated to a temperature of 142 degrees for 30 minutes before it was bottled and distributed.

It seemed a hopeless task to remedy this situation. Laws and regulations would have to be drastically enforced. Years of public education would be necessary before people could demand intelligently what the physicians were calling for.

With this problem before us we attempted to inaugurate rules and regulations to protect the milk supply, by first determining the health of the cow, the character of the feed and the care that she received. At this time we determined the fact that the heat of summer and extreme cold of winter influenced the character of the milk. It became necessary to provide stables in which the cows could be kept reasonably cool in summer and warm in winter. The nature of the feed, the way

it was made and harvested, the manner in which it was fed all became problems of investigation.

Up to this time the cow was considered the forage and grain scavenger. Whenever a grain was not fit to be sold or whenever hays become musty and brown, they were fed to the cow. Later we found this to be a dangerous practice from the standpoint of producing a nutritious milk.

Nutritious Milk Is First Consideration

It seemed that we were constantly encountering a mountain of difficulties, and rather than work on a system of milk preservation it seemed more important to work on a system of production which did not require any processing except cooling. The more we worked with feeds the more we began to realize that a large number of intricate nutrients, minerals, enzymes, plant pro-hormones, vitamins, etc., were destroyed by improper methods of harvesting and curing, which finally affected the cow's health and the nutritional properties of the milk. It seemed that the simplest process was to start regulating the production and begin making good milk, which can be made only through nature's process by feeding good protective feeds and giving the animals good care. After these problems were solved the extraction of milk and the bottling and delivery were comparatively simple, even though not as profitable as the simple purchase, pasteurization and distributing process that had been instituted, and which of course did not take into consideration the complete health program that was involved.

The sole purpose of the dairy business is to supply a highly nutritious, healthful food to mankind, children especially, who depend upon it entirely as a food. It is granted that the business must provide a fair remuneration for all concerned. It should therefore be the aim of the people in the industry to maintain in general the healthfulness, especially the nutritional features of the milk, by constant investigational work, rather than merely to seek methods to reduce costs which, if not regulated, result in a reduction of milk nutrition which happened when trying to remedy the evils of insanitary operations by pasteurization. So today it becomes necessary to remedy nutritional deficiencies, and this likewise becomes a problem for the health department. It is just as dangerous to destroy life through nutritional deficiencies as it is to destroy it through infections. This then is one of the first attempts to stamp out deficiency diseases by preventive medical practices—the ideal type of medical care.

A clean milk supply is not complete unless this clean milk has in it the proper nutritional factors. In our field of investigation, as far back as 25 years ago, we discovered poor nutritional milk from high-producing cows. As time went on we discovered that this factor was due largely to the character and kind of feed given.

Before a test for maximum production by forced feeding a cow should be in good healthy physical condition; but when the proper feed nutrients were not supplied in sufficient quantity, or in such form that they could be properly metabolized, the cow began to produce inferior diluted milk and frequently failed in health. However, the nutritional factors of the milk were deficient long before health failed in the cow.

Following this observation we were led to determine what factors increased the production and, likewise, what factors were necessary to maintain the higher nutritional value of milk. These factors were determined by growth curves of experimental rats, the increased quantity of red corpuscles and hemoglobin in the blood, and the increased bony calcification.

Certain special pasture systems were introduced. The grasses were fertilized with special fertilizers and mechanically dried hay became a factor for winter production. By germinating grains, hydrolizing both hays and grains and by introduction of various minerals we succeeded not only in keeping up the flow of milk and maintaining the nutrition but at the same time increased the reproduction and developed healthier calves from healthier cows.

Natural Milk Best

With the introduction of the essential factors into milk through feed it was quite essential to maintain all by leaving the milk in its natural state as it comes from the cow. Even though milk is produced normally in the udder, it does not necessarily follow that it will be normal after it has been exposed to air, cooled, transported, pasteurized and bottled. It is perfectly evident to every feeder of animals that the young are more healthy when the milk is obtained directly from the udder than if they are fed on the same milk after it is drawn and processed. Milk drawn from one-half of the udder of a group of cows was fed to a group of calves some time after it was drawn, while another group of calves was allowed to nurse on the other one-half of the udder of the same cows. The second group was superior to those fed from the bucket. (A practical demonstration of a better milking operation

which saves more of the nutrients in the milk than are ordinarily preserved by the usual methods can now be seen daily at Randleigh Farm.)

A great many such problems present themselves constantly for investigation, but this quite thoroughly demonstrated to us that chemical changes or deterioration were constantly taking place in the milk, even at low temperatures, after it left the cow. It therefore becomes necessary to consider methods which will stop the deterioration, or to find more rapid methods of delivery of milk from the cow to the point of consumption.

Pasteurization does not supply these nutritional factors, nor does it preserve them to any great extent. After taking all the different scientific phases into consideration, our experiments led us to believe that the way to develop the dairy business is to improve the production of the milk supply (1) by strictly enforcing proper sanitary regulations that will protect the public health, (2) by providing milk from healthy cows, (3) by seeing that proper feeds are provided, (4) by giving the cows proper care, (5) by preventing contamination from contagious disease and (6) by providing sanitary methods of milk handling and distribution. In other words, this is a preventive method, which is, of course, the ideal method of controlling disease.

It is fully granted that pasteurization does destroy such common disease germs as typhoid, diphtheria, etc., but does not always destroy all the tuberculosis germs, especially those in the granular stage, nor heat-resisting streptococci, anthrax and some viruses and molds. It is much better to prohibit the entrance of bacteria in milk rather than to attempt to eliminate them after their introduction through carelessness. Likewise pasteurization detrimentally influences the natural and normal nutritive qualities of milk even though mildly, and of course it is another handling procedure which allows recontamination. If pasteurized milk is reinfected or contaminated with bacteria, it becomes much more dangerous than if not pasteurized in the first place.

Pasteurization kills the lactic acid bacteria which are so beneficial to the intestinal flora of human beings, especially of children. Thus after pasteurization milk can not sour because these bacteria are killed but the heat-resisting putrefactive bacteria remain alive and cause the milk to rot. Old pasteurized milk is toxic and often allergic because of the denatured proteins that are formed. Such milk is at best a very poor food.

The constant discussion about low bacteria count in milk, we claim, is necessary but is not of greater value than the nutritive factors. Milk of toxic character is often produced when feed conditions are not the best. Such milk can not be improved by pasteurization.

It is highly important that the cow receive plenty of green feeds in summer. They provide the proper substances to develop increased hemoglobin and red corpuscle formation and stimulate the resistance to infection to both the cow herself and her milk. A hay which provides a high percentage of minerals and vitamins keeps the digestive tract of the cow in good condition and assists digestion.

Even such a small item as iodine, which is necessary only at the rate of $1\frac{1}{2}$ grains per day per 1000 pounds of weight, if lacking in the food supply in a proper organic combination, interferes with the complete development of the cow. It likewise affects the development of the calf that she produces, and it is well demonstrated that milk fairly rich in iodine has a decided influence in preventing simple goiters in mankind, especially in children. We have been able practically to eliminate goiters in calves by feeding some form of marine vegetation or inorganic iodine. Pasteurization will not improve or prevent a goitrous condition; this can be accomplished only through the proper feeding of the cow.

Iodine compounds need not necessarily be derived from marine vegetation. They can be secured better from hays grown on soils fertilized with iodine. There are needed also certain amounts of calcium and phosphorus to form bone and teeth. Calcium is the primary factor in increasing resistance to some of the infectious diseases. The chances for respiratory infections, such as pneumonia, can be decreased by feeding green hay, which is the natural source of a provitamin for vitamin A. Aside from caring for cows well, one of the principal ways to increase the protective factor or resistance is to give feeds that are properly combined with proteins, carbohydrates, fats, minerals, vitamins, etc. This seems to stimulate the resistance to disease in the cow, and the milk from such an animal seems to produce a similar effect upon the human body.

It is highly necessary to gauge the feeding operations and care of the cow with an increase in milk production, so that she may produce milk with the same protective substances as when she was producing a lesser amount. Properly protected milk means more than simply safeguarding it from bacterial infection and allowing miscellaneous

and haphazard production, and then to attempt to correct the conditions by pasteurization.

Farm Inspection Necessary

Attempts have been made to introduce bills into various state legislatures which provide universal pasteurization through the guise of platform inspection. Platform inspection is carried on merely at the distributor's platform. To my mind this is superficial. It is true that a sediment test and a bacteria count are made. The temperature of the milk and general appearance are taken into consideration, but there is no inspection of the source of production, nor are the care, health and feeding of the cows considered.

With this method of inspection, milk can be produced at greater distances from the point of distribution, which naturally means a cheaper milk. However, milk loses some of its nutrition through decomposition when transported long distances. This happens no matter at what temperature it has been kept. Pasteurization is necessary for this kind of milk, and it must be subjected to high temperatures which cause it to lose many of its vitamins. Orange and tomato juices are often fed to counteract this loss. However, while this is an improvement, it will not entirely fulfill the requirements that a good natural milk supply would furnish.

With all the faults I have mentioned I do not want to speak disparagingly of pasteurization of milk where it is needed, for raw milk produced in an insanitary manner or unprotected is dangerous and should not be sold. Many dairymen have been forced to pasteurize, due to the insanitary conditions which they maintained; and in many cases it would be a favor to them if they were forced to stop producing milk and go into some other line of work for which they are better fitted. Filthy milk should not be tolerated, and surely no board of health or city council should permit it to be sold. But they should go further and see that the cows are healthy, properly fed and cared for in order to make a wholesome, nutritious milk for the consuming public. Universal pasteurization blocks the way for new and better development in milk production, and no board of health should be permitted to relieve itself of responsibility just because of the fact that the milk supply of a city is pasteurized.

Feed deficiency is a problem that is just as insidious as immediate infection. The pathology of food deficiencies presents itself more slowly, but develops with certainty later in life. It is for that reason that no

health department should absolve itself from the responsibility of these conditions that develop later under the guise of pasteurization, which merely takes care of the infective end of the milk supply.

Universal pasteurization leaves the way open only for improving the pasteurization process, which is not necessary if a good milk is produced. I deplore the motives of some men who either do not understand the whole story of dairying business, or who are selfish. The channels of free competition outside the realm of destructive competition must be left open. Sooner or later people are bound to resent such restrictions which concentrate too much power in the hands of a few. Such a condition would soon put the milk business under a utilities commission.

Even though pasteurization did embrace all the virtues of the milk business it would be unwise to restrict all milk to this process. Some avenue must be left open for constantly arising developments which will improve the milk supply. The members of the Natural Milk Association have this in mind.

The men producing natural milk are under medical supervision and their method and practices are such that the milk contains practically only bacteria of the favorable lactic acid type, which are necessary in milk for the control of the intestinal flora of the bowels of the child and consequently are a great protection. These are largely destroyed in the pasteurizing process. If pasteurized milk is kept too long, especially if it does not sour, it is likely to create digestive disturbances in the intestinal tract. Clean raw milk is a combative agent to intestinal putrefaction because of the lactic acid development.

Conditions similar to Mr. Kenan's at Randleigh Farm should be found on other natural milk farms. One farm averages less than 2000 bacteria per cc. for the year. In the city where this milk was distributed the pasteurized milk averaged nearly 50,000 bacteria, which means that if the milk was properly pasteurized, there must have been approximately 90 percent more bacteria in it in the raw state before being pasteurized. Nevertheless, the health officer insisted that all the milk should be pasteurized, even though the natural milk is free from high heat-resistant bacterial mold spores and virus of the type that pasteurization does not destroy.

Health Boards Can Help

Men who have charge of the supervision of milk ought to encourage those who are attempting to produce high-quality milk, rather than

promote a miscellaneous supply of low-quality milk with such a degree of sanitation that its safety may be questioned even after it is pasteurized.

Sometimes we are informed that the raw milk of a city is so clean that the chances for contracting diseases are remote. If this is true the investment for the sanitary provisions are too high for the price that is ordinarily paid for milk. If the price is raised above that of other localities where these conditions do not exist, competition will drive the ordinary distributor to buy the insanitary milk at a lower price. The attempt to restrict the territory for which milk can be purchased is supposed to solve this problem.

I have not seen a locality where all the cows are tested and milk is produced so clean that it is safe, yet had to be pasteurized. Would it not be far better and more practical to take the conditions as they are and boil or at least pasteurize the milk at high temperatures and gradually educate the producer for better production and then use the natural milk producer as an example of what good production means?

I fully realize the difficulties encountered, for usually the distributor lives and votes in the city and the producer-distributor lives in the country; and the authorities, especially the inspectors, are often at a disadvantage in enforcing the sanitary laws as fairly as they would like to.

We also have encountered many unfair advantages taken of natural milk producers, who really ought to have the help of the health board since they are attempting to furnish a better milk supply. We have a case in Ohio where a city has adopted universal pasteurization. Close to its border is an ideal natural milk plant in which the cows are constantly supervised and tested, the milk is drawn under vacuum into bottles direct and no outside contamination is possible. The teat cups are sterilized after each milking and the teats are sprayed with antiseptics. For over two years this milk has been tested in various ways for experimental purposes. The board of health has scored the plant 100 percent repeatedly. This milk, with all its merits, can not be delivered in the city, while milk that is very insanitary can be delivered into the city providing it is pasteurized. Fortunately many people of the city recognize the superior value and safety of the milk and they come out to the dairy to get it. It is needless to comment upon this situation which prevents new development in production and blocks progress.

Another instance has come to my attention recently. A board of health compels a natural milk producer to cap his bottles with hooded

or lip seal caps which are extremely expensive, while pasteurizers are allowed to use a cheap cap. I agree that hooded caps are of great value in protecting the top of the bottle over which the milk is poured, but it must be recognized that pasteurized milk needs even greater protection in this respect when it is poured out of the bottle, since contaminated pasteurized milk is more dangerous than contaminated raw milk. Raw milk has some antiseptic properties, such as active white blood corpuscles, that pasteurized milk does not have.

Pasteurization Alone Insufficient

There are men who present the radical side; they contend that all cows are more or less diseased and that there are insufficient means by which this can be determined, and that there are constant chances for a contaminated milk supply. We grant that with all the tests applied there is still an extremely small possibility for such a condition. Certain diseases might go unobserved for a short time, but this is of small importance compared with the highly resistant bacteria, the molds and the virus still left in pasteurized milk. The partly metabolized feed nutrients and the improperly synthesized constituents of the milk from unhealthy cows fed poor feeds produce obnoxious chemical changes in an otherwise normal milk which is not influenced by pasteurization.

Pediatricians have contended for years that the milk supply that needs to be pasteurized should be boiled or at least brought to the boiling point for three minutes to prevent the greater part of the diseases that may arise from these heat-resistant infective conditions. This, of course, spoils the cream line—the sales advantage. In natural milk there is the added protection of lactic acid bacteria and the germicidal effect which holds many of these infective conditions in subjection without destroying the nutritive factors. The latter method holds greater possibilities for developing a good, healthful milk supply than any heat methods such as pasteurization.

A recent experience with an outbreak of anthrax on a farm where they have been pasteurizing milk has given some concern. While there is no fear of danger from the milk supply direct, for usually the infection kills the animals so quickly that there is barely a chance for contamination from that standpoint, it is feared, however, that the infection may be carried around and spread on the utensils and thus might accidentally get into the milk supply. The deadly disease anthrax can not be destroyed by pasteurization. Boiling is absolutely necessary

to destroy the infection. Proper supervision of the place where the cows are kept, allowing them to drink water from only clean troughs in properly fenced pastures which prevent scavenging animals from getting into the fields, and proper milking apparatus make the supply of milk safer than to allow a miscellaneous milk supply to come from a place without supervision and with acceptance after pasteurization by the board of health.

It is for this reason that attempt has been made to develop milking machines where the supply of milk is delivered into the receptacle without coming in contact with air, eliminating that possible source of contamination. Wells of Boston has shown that many viruses are air-borne. Machines are washed and sterilized without using cloths or brushes, which are sources of contamination, such as is the case for exposed surfaces and coolers.

These experiences have been gained from thousands of clinical observations made on young, growing and producing animals under various conditions, combined with the experiences of some of the most careful and successful medical men who have gone into the matter scientifically and experimentally. There is still so little known about this whole subject that we should prefer to stay on the safer side, the side of nature, until we arrive at more definite conclusions about the clinical observations that constantly present themselves in the practical field and with experimental animals.

Gradually we must approach a better method of dairying. People will demand a better milk supply as time goes on, and it becomes necessary to know how to improve the supply in accordance with experiences, combined with the practical application of the scientific developments as they are discovered.

As conditions present themselves now a milk supply coming from untested cattle infected with *B. abortus* and mastitis must be heated to a point close to or even above the boiling point for safety in human consumption. This gradually brings us to the problem of sterilization of milk, such as condensed and powdered milk which the consuming public has accepted in recent years to a great degree. Still, while such milk is rendered bacteriologically safe, the nutritional value of such milk, which is influenced by the feeding operation, can not be compared with clean raw milk produced from healthy, well-fed cows. It must be granted, however, that for cooking and manufacturing a milk of this kind should have a prominent place in the human diet. Yet milk

produced from unhealthy, poorly fed cows and produced under insanitary conditions, even though there is some system of inspection, should not masquerade as a clean, wholesome drinking milk such as we would like to feed our children.

Most cities that have passed ordinances allowing only pasteurized milk for city consumption have ignored rigid inspection of the dairies on the theory that pasteurization corrected all insanitary difficulties. As a result such cities usually have the filthiest milk supplies.

In addition, the term "pasteurization" as a rule has a demoralizing influence upon the producer, which has been unfortunate. Instead, there should be pursued an educational policy that would make for constantly improved conditions of general sanitary policies.

The duty of the U. S. Public Health Service is to prevent disease. Clean, raw, nutritious milk as herein described is a most valuable means of preventing diseases (both infectious and deficiency diseases). This can not be said of pasteurized milk which has obscure sources, which diminishes the vitamins, alters and denaturizes proteins, precipitates valuable minerals rendering them non-available, removes the volatile oils and stimulating gases, destroys the lactic acid bacilli (allowing a more dangerous type of contamination) and gives the public a false sense of security, hinders progressive healthful dairying, encourages carelessness and frequently is responsible for toxic allergic states in babies. Additions, such as vitamins, minerals, etc., are expensive and most people will not buy them or be annoyed by including them.

Realizing that the universal production of such a milk as is advocated herein will be a time-consumption revolution of the dairy industry, health boards and the U. S. Health Service should be aware of and encourage changes toward such a goal. It is a national health maintenance problem attacked through preventive measures which would result in one of the country's most valuable assets—another means of disease prevention.

Clean milk has no equal in the realm of foods. It is necessary in the growth and development of the human race, but through this superior intricate balance of minerals and other nutrients it becomes the most protective food for the matured man and woman, especially as senility approaches.

Old Age Might Be Postponed

"Old age can be postponed from 10 to 15 years by eating a diet containing large amounts of calcium, protein, vitamin A and vitamin G,"

Dr. Henry C. Sherman, professor of chemistry, Columbia University, stated in a report made at the Carnegie Institution of Washington. The studies were conducted on rats because the chemistry of rat nutrition is much like that of human nutrition.

"The rats were divided into two groups. One group was fed a diet containing enough vitamins and other necessary food substances for the animals to grow, remain healthy and bear young. The second group of animals was given what Dr. Sherman calls an optimum diet, differing from the first by having more milk in it. The extra milk supplied more calcium, more protein and more of vitamins A and G. The animals on this optimum diet lived much longer than the first group of animals and in addition had more vitality.

"Interpreted in terms of human life, Dr. Sherman said that the gain the rats made was equivalent to extending the span of human life from 70 years to 77 years. The period known as 'the prime of life' was extended even more in proportion. Signs of senility that would appear in normal individuals on an adequate diet at 65 years of age would be postponed by the optimum diet to 75 or 80 years.

"According to present knowledge, Dr. Sherman believes life and vitality could be extended by a moderate increase in the calcium of the diet, by eating not more than twice the minimum amount of protein and by taking about four times the amount of vitamins A and G needed for normal nutrition."

The quotation above is from *Science News Letter*, April 4, 1936. It is printed here in support of the feeding program many dairymen now follow with their cattle, and the results are strikingly similar. As described in these pages, these cows receive their extra protein, calcium and vitamins through the "green" of grasses, sprouted grains and dehydrated hays in large part, along with other feeds and minerals.

Milk from cows so fed becomes the important food of the nation, for milk has no equal among foods for all ages.

CHAPTER XXXIII.

THE GREEN PLANT

By DR. O. L. INMAN, Antioch College, Yellow Springs, Ohio.

UNLESS the geologists and the astronomers are mistaken, a long time must have elapsed between the formation of the earth and the coming of the green plant. Before the appearance of this vegetation there could have been none of the common types of animals now present. Unless there was other life that left no record, only a few kinds of sulphur bacteria could have existed.

As protoplasm is known today, it is a complex mixture of water, proteins, fatty-like substances, carbohydrates and inorganic salts forming a gelatinous mass which the chemists call a colloid. Insofar as has been discovered, this colloid has not changed its fundamental nature in millions of years, and there is reason to suppose that it is an immortal substance as long as the environment of the earth is suitable for its growth and reproduction. While protoplasm may be expressed in an almost inconceivable number of plant and animal forms which vary in many of their characteristics, a certain uniformity is constantly maintained.

Just how the green pigments or chlorophylls arose is not yet known, but it is evident that these chemical molecules were manufactured by the protoplasm itself. The chlorophylls *a* and *b* are found in all plants that make their own food. The chemical nature of these molecules is fairly well defined. They are simple as far as the number of elements is concerned, for, of all the known 93 chemical elements, only carbon, hydrogen, oxygen, nitrogen and magnesium are present. When it comes to the arrangement of these components, the molecules are not so simple. Yet, they are not more complex than many of the substances we use and talk about every day, as, for example, egg white. Chemists have long noted that the red pigment in blood and the green pigment in plants have many similarities in the arrangement of the chemical elements in the molecule. This has led to the belief that hemin, the red blood pigment, and chlorophyll, the green plant pigment, had similar origin. Our best calculations show that the formula for chlorophyll *a* is $C_{55}H_{72}O_5N_4$ Mg. and for chlorophyll *b* is $C_{55}H_{70}O_6N_4$ Mg.

It is not wholly a matter of chemical structure that makes the chlorophylls interesting, however. They are light absorbers and thus pick

up the sun's energy which is used so extensively by the animal kingdom in the form of sugars, starches, proteins, fats, coal, oil, rubber, alkaloids and numerous other compounds.

The light absorbed by the chlorophylls is primarily in the region that we can see with our eyes, that is, the visible spectrum. Just what happens to the absorbed light energy, however, has not been explained. It is clear that some of this energy reduces carbon dioxide, thereby freeing oxygen. It is also believed that it may be necessary for some of the energy to decompose water into hydrogen and oxygen. After these decompositions, the carbon, hydrogen and oxygen finally reform into the kinds of molecules mentioned above. What advantage, asks someone, is there in decomposing two or more substances by absorbing light and then recombining them into new types? This can easily be demonstrated by trying to burn water or carbon dioxide or by trying to make a meal on these molecules.

The fundamental operation that the green plant performs is to take molecules that have no energy readily available to us or to the living cell and store this light energy in a rather stable form in chemical molecules. If one wishes to recover the light that has been stored, he may do so by taking coal or wood and burning it so that it gives off light. Since it is chiefly carbon from the carbon dioxide that is needed for the storing of energy, much of the oxygen is given off to the atmosphere. This use of carbon dioxide and release of oxygen by the green plant when in light is, without doubt, one of the reasons why we have an atmosphere which is rather uniform in the amount of carbon dioxide and oxygen. If all chemical reactions took up oxygen and released carbon dioxide, we might find that there would not be enough free oxygen in the atmosphere to burn a piece of wood or to maintain an animal, a plant without chlorophyll, or a green plant in the dark. In the last two instances, plants use oxygen and give off carbon dioxide just like animals.

It may be a little difficult for most people to realize that their breathing, walking, thinking, and the warmth of their bodies are linked closely with the living cell, the chlorophylls and the sun. When studying such relationships as these, it is difficult to conceive of a series of accidents which would have first formed the necessary environment for life, then produced protoplasm, and, finally, introduced into the protoplasms green pigments which would absorb light and fix it in the form of chemical compounds which can in many cases be stored for

future use. This whole arrangement points to some ordered system or design in nature. The reason it is so hard for us to understand this is because we probably see only a few links in a long chain of events.

Also fascinating and closely related is the arrangement of leaves on many plants so that each leaf secures the maximum amount of light. On the maple tree, for instance, the leaves are opposite on the branch and any two adjacent sets of leaves are at right angles to one another on the stem. In this way the upper set of leaves is not directly shading the next lower set. In other plants this is taken care of by a spiral arrangement of the leaves on the stem. Thus, sunlight can filter more readily throughout the whole plant.

What does all this have to do with a good glass of milk and a fine cow or horse? It must be clear that were it not for the food making process in the plant there could be few, if any, animals on the earth. A glass of milk is likewise a product of so much sunshine. Furthermore, milk must contain the proper minerals and plenty of vitamins. It has been known for several years that milk of high vitamin content was produced by a dairy herd during the summer when it could graze in green pastures, getting stored sunshine from the grass and absorbing it through the body. For the winter months in the north temperate latitudes, food must be preserved. This must be done with great care in order to avoid the loss of the precious vitamins and chlorophylls. Even the cow seems to know that the fresh green grass or the well-preserved green hay is better food.

Many of the advantages of absorption of sunlight and the fixation of chemical molecules would be lost if man did not learn how to preserve some of the more unstable and yet most necessary products of green plant manufacture. Some of the problems involved in the storage of plants so that high content of proteins, vitamins, hormones, carotinoids, chlorophylls, and fats may be retained are:

1. The control of the hydrogen-ion concentration or the acidity and alkalinity of the forage.
2. The control of enzyme activity so that the proper changes take place and the reactions are inhibited at the right point.
3. The prevention of too much oxidation or reduction of these unstable compounds.

The temperature of storage, the presence of strong light, the abundance of free oxygen, and a large percentage of moisture usually tend to encourage the decomposition of the desirable substances.

Almost all the vitamins, carotinoids, chlorophylls, and many of the proteins and fatty-like substances have reactive chemical groups. One of the common ones is the double bond linkage between two carbon atoms in the molecule. Biochemists have found that such delicately balanced molecules as those listed above often need to undergo only very slight shifting of the bonds or groups within the molecule to render them physiologically inactive. Therefore, we have here a far more difficult problem than the mere preservation of carbon compounds involved in the storing of coal, oil, etc. The problem also differs from that of storing the sun's energy directly as heat or as electrical energy through some mechanical device.

When more is known about the numerous supplementary diet factors which the green plant manufactures, there will be more appreciation for the value of increasing these items in the rations for all animals. Here then is the borderland where fundamental studies in photosynthesis, food chemistry, food preservation, and nutrition meet in an attempt to understand nature's principles better and to apply that knowledge to the promotion of better health.

CHAPTER XXXIV.

BLOOD, LIFE AND THE PROGRESS OF THE MILK INDUSTRY

LOWELL ERF, M.D., Cincinnati, Ohio.

SUCH widely diversified subjects as are presented in this title would seem to have few correlating links. There are, however, many connections among these subjects, and the future will unveil many more.

Blood

Blood is the most abundant fluid tissue of the animal body and is composed of cellular or floating elements and the plasma or fluid element. The plasma makes up about 60 percent of the blood of the human being, who contains normally about 1½ gallons of blood. Therefore, all cells of the human body (liver, lungs, heart, muscles, bones, brains, kidneys, glands, etc.) are bathed in about one gallon of fluid. A gallon of water is insufficient, most folks will admit, to cleanse the skin of an adult (a bath), and yet one gallon of plasma is sufficient to both cleanse and nourish all the "inside cells" of a human being. This seems incredible, for vastly greater proportions of fluid are necessary when tissues are artificially grown on culture media. However, the fluid in these circumstances is not circulating and constantly being cleansed as the kidneys, liver and lungs do to our plasma.

Another incredible fact is that plasma is one of the oldest substances in animal life and one of the few things passed down through the generations directly. According to the Darwin theory, the first animal was an unicellular body swimming in sea water. As eons of time progressed, this one-celled animal developed into many cells, all exposed to sea water. Later in order to insure compact organization for protection, the animal progressed to a tubular stage where sea water could be drawn through it. Still later as the animal world evolved, animals circulated sea water within their cavities and some retained a small portion of sea water, which developed into the plasma so that these animals could leave the sea and live on land. There is considerable scientific proof that human plasma closely resembles the old sea water of millions of years ago. It is well known that hospitals universally use, routinely, saline or sea water for intravenous use (injection into the veins). It is the fluid used to help nature flush out bodily

wastes. In fact, saline is the basis for most medicines that are given directly into the human blood stream.

It is impossible to realize just what an important function plasma or old sea water has for all animal life. It is the only thing that comes in contact with all the body cells; giving to some, taking away or extracting from others. (It also flows through many cells.) It takes fats, proteins, carbohydrates, minerals, enzymes, hormones from the intestines and places these materials in contact with all the body cells. Hormones, enzymes, catalyzers and highly complex chemicals which must be in proper proportions (else deficiency diseases and abnormalities will develop) are taken from the liver, adrenals, thyroid, pituitary, gonads, pancreas, etc., and through the plasma are given to the muscles, brains, eyes, ears, skin, bones, connective tissues, etc. The wastes, such as urea, uric acid, creatinin, carbon dioxide, etc., are brought back and disposed of by the kidneys, lungs, etc. Plasma is the feeder and the general caretaker of all the body's cells, and vastly more intimate with the body cells than the nervous system which is only the communication system.

Old sea water contained all the chemical elements, and even today in Delaware there is a chemical extracting plant that is extracting bromine, iodine, gold, etc., on a profitable scale from the sea. When mineral deposits become scarce on land, the sea will be "mined" of its chemical elements. The seven seas abound in minerals of all sorts. Normal animals have plasma or sea water that contains all these elements in a harmonious balance for the existence of that animal. It is essential for the animal to replace utilized minerals by eating or digesting more. The plasma carries many integrating products, the humoral or semi-fluid agents, such as insulin, cortin, thyroxin, antuitrin, oestrin, adrenaline, pituitrin, folliculin, prolactin, parahormone, androsterone, testosterone, etc.

All animal life defends itself through two general mechanisms, primarily known as the humoral defense system and the cellular defense system. The former deals with body fluids and its contained chemicals: antibodies, hormones, enzymes and various cellular secretions. All these, of course, are found in the plasma of the blood. The cellular defense mechanism is composed of mainly the white blood cells, which likewise are found in the plasma.

The cellular elements or floating elements of the blood are not all known and usually only three types are described; known as the red

blood cells, the white blood cells, and the platelets. The red blood cells are small dished-out elastic discs, which are the transporting vehicles for hemoglobin, the respiratory pigment for humans as chlorophyll is the respiratory pigment for plants. In other words, hemoglobin has the faculty of easily exchanging oxygen and carbon dioxide. (Oxygen is paramagnetic and reacts with other magnetic materials, such as iron, in the hemoglobin of the blood.) In areas where oxygen is abundant (as in the lungs) hemoglobin will absorb oxygen and discard carbon dioxide; and where carbon dioxide is abundant (as in the muscles), the reverse gaseous exchange takes place—a concentration-gas pressure phenomenon. Hemoglobin contains iron, making evident the animal need for that element. Red blood cells number normally 5,000,000 per cubic millimeter of fluid blood, or 30,000,000,000,000 in $1\frac{1}{2}$ gallons of human blood. Since the life span of a red cell is about 30 days, nearly one trillion red cells are produced by the body daily.

The white blood cells are valuable components of the blood from a defensive aspect; the so-called cellular defensive system. There are many kinds of white blood cells, such as the polymorphonuclear, the lymphocyte, the monocyte, the eosinophile, the basophile, the reticulo-endothelial cell, the clasmatocyte, etc.; and only a few of their functions are known. The human body through evolution has developed necessary defense mechanisms, and against active invasive plants (such as the various pus-producing bacteria) the body pits the polymorphonuclears first. They are supposed to pin their opponents (the bacteria) to the mat and devour them. The lymphocytes are supposed to attack the slower-growing plants or bacteria, such as the tuberculosis germ. Eosinophiles are frequently associated with infestations of the body by worms, and they also appear when allergic poisons preside in the body. Whether they are a defensive mechanism or not is unknown. Thus one can see that the body has a cellular response to many attacking forces. There are about 8,000 of these white blood cells per cubic millimeter or about 50,000,000,000 in $1\frac{1}{2}$ gallons of human blood; and since each lives about five days, nearly 10 billion of these white blood cells are produced daily.

The platelets, or the third cellular element, are closely associated with clotting or coagulation of blood. Since there is but $1\frac{1}{2}$ gallons of blood in the body, it has developed a means of insurance against blood loss. If there is a hole in one of the tubes of the radiator of an

automobile, the water soon runs out. Not so with blood. When there is a hole in one of our tubes, these little platelets will dam up the leak. They disintegrate at a wound or around a foreign body (as dirt) and throw out a mesh (or fishnet) which will catch some of the red blood cells and develop a plug or clot. This is non-fluid blood or tissue (like tissue of other organs), and it has lost its valuable function, that of mobility or fluidity. Fortunately, the body has a wide margin of safety in regard to blood loss. One pint of blood can be removed suddenly without any strain on a normal body, and the body can lose half a gallon, or one-third of the blood, without serious strain if the blood slowly escapes (as in gastric ulcers or bleeding wounds).

Where are these cellular elements of the blood made? Some of the blood cells are a product of the bone marrow, just as insulin is a product of the pancreas. The bone marrow is an organ larger than the liver, and is responsible for the production of the red cell elements, the platelets and about 70 percent of the white cell elements. The lymph nodes and spleen are responsible for 25 percent of the white cells and the reticulo-endothelial system is responsible for the remaining five percent.

Bone marrow is found within nearly all bones of the body. If the bone marrow from the "inside" or cavities of all the bones was removed, one would have a yellowish-red fatty mass weighing about four pounds. Nature was a most efficient organizer when she worked on bone marrow. A tube is stronger than a solid bar (when composed of the same quality and quantity of material), and nature wanted a strong but light structural framework. She utilized the space within the tube for the manufacture of polymorphonuclear leucocytes, the red blood cells and the platelets—the bone marrow, an organ that must be very warm for efficient service.

We all know that when bacteria invade our bodies, our temperature goes up or we develop a fever, which starts the blood to circulate faster and speeds up the bone marrow, which makes more leucocytes (or white blood cells) to attack the invader. So nature put the marrow inside the bones, in over-heated confined cavities—a very warm atmosphere and rather stuffy because little oxygen (or ventilation) gets in. This stuffiness or suboxidative environment is supposed to be responsible for the development and maturation of the red blood cells. The progenitor of the red blood cell is a large cell quite similar if not identical with the progenitor of the leucocytes or white cells. As ma-

turation progresses, the red cell precursor gradually incorporates hemoglobin; and just before the red cell is injected into the blood stream, the nucleus or reproductive feature of the cell is removed, so that red blood cells can not reproduce in the blood stream. (This is not true of white blood cells.) Red cells have only one essential purpose, that of transportation of oxygen and carbon dioxide.

The lymph nodes are little masses of lymphoid tissue scattered throughout the body and stand as sentinels or outposts night and day, guarding against infection. They are the bodies that swell (called kernels) under our arms and in our groins when we have an infected finger or toe. They produce, along with the spleen, lymphocytes or about 25 percent of the white blood cells.

The reticulo-endothelial system is much like a sewer. This is composed of cells (or manholes) along the capillaries (or streets of the downtown area) of the liver, spleen and marrow. They engulf debris as it floats along the curb. This system produces the monocytes and clasmatocytes, the so-called phagocytic cells.

Life

What an epoch when bacteria were found and shown to be both beneficial and harmful to the human body! What an epoch too when the viruses (disease-producing protein molecules), fungi, parasitic agents (malaria), and yeasts were likewise shown to be both beneficial and harmful. What an epoch when minerals, hormones and enzymes were shown to be both beneficial and harmful in various concentrations. What an epoch when other agents were found to affect the human body, such as spiroketes (syphilis), protozoans (amoeba histolytica-Chicago dysentery) and radiations (ultraviolet rays, cosmic rays, x-ray, gamma rays, neutron rays, etc.). Recently it has been discovered that dead, apparently inert proteins can, when in contact with living cells, reproduce and attack plants. This is either a super-catalytic or autocatalytic process. Soon someone will discover agents responsible for various tumors of the body, such as the cancers, the carcinomas, the sarcomas, the fibroids, the leukemias, in other words, the new growths or parasitic cellular masses. They probably all have a common cause much like many infections have a bacterial etiology. Possibly new growths result from focal ischemia—a pure mechanical and chemical problem. Hypertension (or high blood pressure) can be produced in dogs by reducing the flow of blood to the kidney. Just partly stopping

the normal amount of blood flow to the kidney or even to one kidney will result in high blood pressure. Other such mechanics are closely related to blood.

One can thus see how important our blood is to the integration of our bodily processes. It carries both the defense and the attacking units. It carries food minerals, hormones, enzymes, wastes and innumerable chemicals, all of which are essential for bodily organization and life. Human life depends on blood and blood depends on many chemical combinations, and the building stones of these chemical combinations must be ingested into the body. Therefore one must eat the foods that contain these essentials.

Radiations for needed energy, as Dr. Inman has so interestingly brought in his discussion on chlorophyll, is also an essential for life. Chlorophyll is the light absorber or energy absorber (and Dr. Inman has shown that the products of chlorophyll can be burned in many instances and light re-emitted). Apparently all matter is electrical, and the following is an attempt to show how this is true.

It is rather grotesque to think that everything on this earth is but a combination of 93 chemical elements, but the chemists assure us of this fact. The physicist tells us that these elements are but combinations of positrons and electrons (positive and negative charged particles) which are in rapid motion. Many of these systems of whirling bodies derive their energy from photons or radiation units which reach the earth from the universes. Just as Dr. Inman has pointed out, life could not exist without the sun rays because chlorophyll is "energized" by sunlight and that allows plants to grow, and that makes animal life possible. The physicist tells us further that some of these radiations (such as cosmic rays which pass through our bodies continuously) come from universes much farther out than any astronomer can see. It seems strange that our life is dependent on things not present on this earth.

The Progress of the Milk Industry

How can we now link up milk with all the preceding discussion? Human beings suckle raw milk from their mothers during the first six to nine months of life. This is uncontaminated milk, and if the mother has eaten good food and lived in a normal and healthy environment, the milk would be most wholesome for the infant. The infant would be consuming the necessary nutrients for a strong blood defense mechan-

ism and thus a healthy life. This milk flows directly from the mammary gland into the alimentary tract of the infant. Human milk is best for human babies. When the Dionne quintuplets were fed milk they were given human milk shipped from Chicago. This human milk was extracted from healthy mothers. To supply human milk to all babies is impossible, but it is possible to supply uncontaminated raw milk obtained from healthy cows.

All bovine milk is naturally clean if the cow is healthy and kept in a normal environment. Tuberculosis bacteria, typhoid bacteria and other pathogenic bacteria are not found in healthy cow's milk any more frequently than they are found in healthy human milk. It is through man's carelessness and ignorance that cow's milk becomes contaminated with dirt and filth (dirty stables, dirty milking utensils, coughing, dirty air, etc.). It is man who puts tuberculosis germs, typhoid germs, diphtheria germs, septic sore throat germs and other pathogenic bacteria into the milk *after* it has left the cow.

There have been three eras in the milk industry. First was that of delivering contaminated raw milk to the public. This proved to be a dangerous practice for the maintenance of our national health. So the Public Health Service of the United States commanded that something be done.

The next era was that of pasteurization. This was an important step for maintenance of our national health. Pasteurization took this contaminated raw milk and through heating and aeration killed most of the bacteria, and bottled the milk in clean bottles that were delivered to the public. Re-contamination of this pasteurized milk, of course, had to be avoided because contaminated pasteurized milk is even worse bacteriologically than contaminated raw milk. Due to our past methods of handling and distributing of milk, pasteurization was necessary for our national safety.

What do heating and aeration do nutritionally to milk? First, as has been stated before, pasteurization kills many of the bacteria but it kills also the lactic acid bacilli which are found in milk of all animals and to which animals throughout the ages have adapted themselves. Likewise, pasteurization has oxidized and partly precipitated some of the minerals of milk. It also removes many of the vitamins and essential oils and gases of natural milk. It, of course, kills the living leucocytes that are present in fresh milk which are bacteriocidal. The natural milk proteins (lactalbumin, etc.) through heat and protein coag-

ulation are denaturized to a degree, altering their solubilities and physical characteristics. The denaturation of the virus proteins through heat is accompanied by the loss of virus activity, and a similar energy is lost through the denaturation of milk proteins.

With all these nutritional qualities eliminated, a baby which must exist on milk entirely will face the possibility of many types of deficiency diseases. Metaplastic changes of the mucous epithelium (such as xerophthalmia and bronchial keratinization), scurvy, rickets, beriberi, pellagra, goiter, and primary and secondary anemia, are all deficiency diseases due to lack of various vitamins, minerals, hormones, proteins, gases, etc. So if these nutritional factors are removed through contamination, aeration, stagnation, heating, etc., deficiency diseases during the physical formative age, first three to five years of life, are probable.

Surely man is not egotistic enough to feel that he can add a little cod liver oil or orange juice and be content that he has placed aerated, contaminated pasteurized milk back into the condition that nature originally manufactured it. Man is totally unable to incorporate properly all these complex chemicals as nature does. Therefore, the blood of babies fed contaminated milk does not get these chemicals and, of course, the infant's life in general is altered.

Now the third great step in the milk industry is that of delivering uncontaminated raw milk to the public; and here again the United States Public Health Service, the physicians, the veterinarians, and the public are striving to have this third step become practical. In other words, the next step is to produce and deliver wholesome milk from healthy cows in the natural state, without contamination, just as every animal receives it during the first six months of life. In other words, the milk in the bottle will be nutritionally, chemically and bacteriologically unaltered.

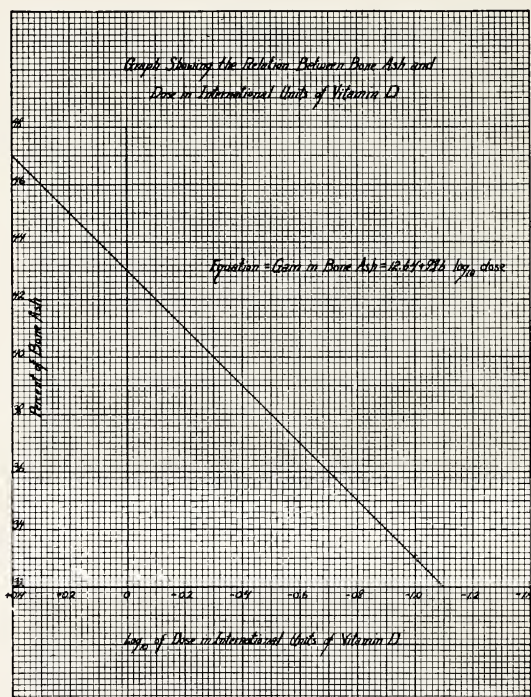
Any interference with the adoption of such a program would not only be stopping the progress and research of the milk industry, but would also be hindering the prevention of deficiency diseases; and it would be interfering with our national program of health maintenance through a preventive rationale. This national problem can be put into effect by the United States Public Health Service, through the education of the public and the cooperation of the national milk companies. Helping nature and humanity through the elimination of contamination is

the very essence of the preventive health program which the United States Public Health Service is striving for.

This third step in the milk industry has been conceived by Professor Erf for many years, and he has worked out a plan which will produce and deliver raw, wholesome, uncontaminated milk from healthy cows. He has a number of these plants in operation now. He has, through the cooperation particularly of W. R. Kenan of Lockport, New York, who has given so much of his time and invaluable help so unselfishly, made possible the feasibility and practicability of producing and delivering such milk to the public.

This has been done by selecting and maintaining healthy cattle which are frequently tested for tuberculosis, abortion and streptococcic infections, etc.; hiring men who are physically well and who likewise are frequently tested for various diseases; and collecting the milk from the cows and putting it into the bottles under vacuum in one single process. In the future the public will demand more of this type of milk, which is so essential for our national health by maintaining blood in an optimum state; and the future will show too a closer relationship between blood and life and the progress of the milk industry.

APPENDIX



Graph showing the relation between Bone Ash and Dose
in International Units of Vitamin D











RANDALL LIBRARY - UNCW



3 0490 1410127 W